

# CHEMICAL & METALLURGICAL ENGINEERING

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## Annual Meeting of The Mining Engineers

THE annual meeting of the American Institute of Mining and Metallurgical Engineers will be held in New York City, February 16 to 19, inclusive. Owing to the congested condition of hotels in New York City it is necessary at this early date to urge all who expect to attend the meeting to secure hotel accommodations well in advance. The local committees in charge of this meeting are making strenuous efforts to provide for the convenience and entertainment of members who come from a distance. In spite of all that these committees can do, however, it will be necessary for visiting members to take all possible precautions to insure finding hotel accommodations when they arrive.

## Mr. Hoover and The Presidency

REPEATED mention of HERBERT HOOVER in connection with the Presidency will be received with gratification by his engineering friends and associates, even though the publicity may be distasteful to a man of Mr. HOOVER'S nature. For several years we have joined with others in raising our voice in support of more active participation by engineers in Government affairs. Repeatedly we have said that the Government would be more efficient if we had fewer lawyers and more engineers in legislative and executive positions, and we see no reason for not extending that observation to include the highest executive position in the Government. The decision of the Democratic National Committee to hold the party convention in San Francisco gives an added impetus to Mr. HOOVER'S candidacy, he being a Californian by adoption. Probably Mr. HOOVER'S greatest claims to political recognition are his undoubted business ability, thorough grounding in economics and familiarity with European conditions. Other possible candidates are more prominent politically, but none of them approach Mr. HOOVER in positive qualifications.

## What Kind of an Engineer Are You?

FOUR kinds of technical engineers are to be reported by the census enumerators who are now taking the fourteenth decennial national inventory. Limitation to four varieties is due to an undersupply of cogs in the great census-counting machine now operating at Washington. Civil, mechanical, electrical and mining engineers are to be the proud possessors of these four cogs. All other practitioners of engineering will be forced to trace back their relationship and claim the one of these four titles that appears to be most becoming to them.

Looking at the matter from the basis of alphabetical

initials of engineering titles, there seems to be one too many cogs supplied. For only three combinations of C, M and E are required to designate those chosen, as well as the left out, chemical, metallurgical, marine, military, efficiency, as well as that large cosmopolitan class called etcetera engineers. However, not wishing to detract from the seriousness of the subject, it may be asserted that engineers as a whole are not inclined to be overly particular about their titles. The reason for this is that, as they become more proficient, they widen their scope to cover an increased amount of engineering activities in other fields.

It is probable that the great majority of the readers of this journal will choose to be counted with the mechanical engineers. Any one of the other three of the four chosen could do the same without stretching their qualifications very far. The civil engineer deals mainly with the static mechanics of bridges, highways, railroads and pipe lines. The electrical engineer has mastered the mechanics of electrical phenomena. The mining engineer has been schooled so that he is able to direct the activities of machines and miners in the bringing forth of mineral and ore. No outsider should register among these specialized groups unless he is very closely associated with one of them and more than slightly familiar with its work.

As the census years go by, it is to be hoped that other cogs will spring forth and that the chemical and metallurgical engineers will be separated from this broad classification, which from its very nature is capable of subdivision without end and must always provide for the etcetera engineers.

## The Steel Strike Officially Called Off

THE steel strike is officially ended and Mr. FOSTER of unsavory reputation has resigned as secretary-treasurer of the committee which deliberately plotted the disruption of the steel industry through a strike for power. Friends of the American Federation of Labor have felt that its reputation for sane leadership and constructive action was greatly damaged by the activities of men of the Foster type. There can be no doubt that the country was never sympathetic with the steel strike, because it was plainly a contest for power and had no justification. Its leaders were avowed radicals, if so mild a term can be applied, and Labor is well rid of them if their retirement from leadership should prove permanent. The strike was a failure from the beginning and resulted only in economic loss to the steel companies and their employees. Steel production in 1919 was reduced by 2,500,000 tons, due to the strike, and laborers lost untold sums in wages. In other words, the strike was a net loss to the country which the public eventually will have to pay.

## State of the Milling Art in 1919

IN THE milling of copper ores as well as in the smelting end, there have been few changes of importance made in existing plants, nor have new plants of large size been built. With high labor and commodity costs and a stagnant copper market, the operator has perforce devoted his attention to keeping his costs as low as possible with the equipment already installed. This does not mean, of course, that research and progress have halted—in fact, everywhere is evidenced the keenest interest in comparative performances.

Crushing and grinding account for the greater part of the expense of concentration, and consequently this department is attacked oftenest by well-intentioned economists. Gyratory crushers seem to be the favorite for coarse crushing—mammoth machines are in operation which receive 70-ton carloads of rock at a time, the size of the pieces being limited only by that which can be juggled on a steam shovel dipper. Doubtless it is cheaper to crush in gyratories than to blast in the mine, but a logical crusher to balance heavy shovels requires openings up to 8 ft. in width. Air-dumped steel cars of the type developed for short-haul railway excavation are favored in recent developments; however, Utah Copper, with its comparatively long haul, still retains its older drop-bottom gondolas. At best such a car unloads slowly and with great labor expense, so in order to save in unloading cost as well as to handle partly frozen ore, that company started operation at its Arthur mill of a new primary crushing plant. A carload of ore from the mine is pushed up an incline by an electric "mule," is clamped down into a cradle, and cradle, car and contents are lifted bodily, tilting sidewise about a pivot several feet above the rail. Ore drops from the overturned car on a huge grizzly made of I-beams and rails, and thence slides into the bell of the coarse crusher. All subsequent handling and elevating ending at the mill-feed bins are done by an elaborate system of inclined conveyors.

For the second stage in size reduction two machines are the favorites, rolls and disk crushers. The latter type particularly has been favored in leaching practice, where uniform size and a minimum of fines are desired. With Symons disks it is possible to eliminate screens, since the machine delivers pieces with one dimension constant. However, large flat pieces will be passed. In case the ore does not break into slabs, this characteristic of the disk crusher is naturally a considerable advantage over rolls, from which pieces with three variable dimensions will come. However, the extreme simplicity and tremendous capacity of large Garfield rolls in many cases will incline the balance of favor to their side.

Two types of vibrating screens have been developed, the Mitchell, used by Utah Copper, and Tyler's "Hummer," installed for trial at a number of places. Both are electrically driven, actuated by the rotation of a tightly enclosed and somewhat unbalanced motor. As high as 3600 vibrations per minute can be given a taut screen surface by such means, their capacity on dry or wet material is tremendous, and if they can handle damp, sticky ore at a reasonable cost, they will surely find a welcome in the crushing field.

For finer crushing the ball mill has undoubtedly come to stay, although LENNOX at the Portland mill believes that Chilean mills have fallen into disrepute largely

because they have habitually been given the wrong kind of feed. Like the ball mills at Inspiration, very much better performances in all respects can be had by giving Chileans a certain amount of relatively coarse material. New Cornelia, in its 500-ton experimental flotation plant at Ajo, is equipped for comparative tests on a special 8 ft. x 36 in. Hardinge conical mill, equipped with grates and with a large open discharge, and two rod mills designed by DAVID COLE, 42 in. x 9 ft. 8 in. and 60 in. x 10 ft. respectively. Rod mills are receiving their share of attention; thus at Nocazari favorable results as to power consumption and tonnage have been had from one designed by MARCY. In passing, one is reminded of the open-end mill tested a couple of years ago at Anaconda, where an old tube mill shell had a tire placed around the open end, and carried on double rolls from a disused drier. Metallurgically the results were excellent, giving a high tonnage at more uniform discharge, with less fines, two-thirds the steel consumption and 60 per cent of the power used in the current practice. The mill was abandoned, however, due to mechanical troubles incident to rapid rotation of such heavy masses in make-shift bearings. It is probable that the rod mill may not be able to crush coarse material in one step, but for grinding from, say,  $\frac{3}{4}$  in. to 20 mesh and with the production of a uniform product, the open-end rod mill has extremely attractive possibilities.

In ball-mill crushing the cost of the grinding medium is one of the two large items of expense, the other being power. Metallographical investigations into the nature of steels used for balls and linings should improve this material to a surprising extent. Screening during stage crushing is also a most important item of cost. In order to economize at this point, dry crushing of ores from  $\frac{3}{4}$  in. to 20 mesh has been tried at two localities in Arizona, in both rod and ball mill, but as yet without success.

As little is known about the fundamental laws of flotation now as a year ago. All mill experimentation, therefore, is empirical, and directed toward increasing recoveries at lower costs, by trying different combinations of oils, reagents and equipment. Very good results have been had with a combination of 60 per cent "X-cake" (alphanaphthylamine) and 40 per cent xylidine, both coal-tar products. In one plant the use of  $\frac{1}{2}$  lb. per ton—of which a third is recovered—is producing a tailing containing 0.15 per cent sulphide copper, and a deflocculated granular concentrate which builds up  $1\frac{1}{2}$  in. thick on an ordinary drum filter. It is impossible to draw general conclusions from isolated results in this dark corner of metallurgical practice, however, since ores vary so much in character from mine to mine, and even from one part of the same ore body to another. Still, many good reports are circulating about coal-tar products, and there is no doubt that the choice of oil has an important bearing on the recovery and grade of concentrates. It is doubtful whether these new combinations will free the users from the shadow of Minerals Separation, since they probably can be legally defined as "oils," and Messrs. SULMAN, BALLOT et al. control patents covering the use of soluble oils.

In pneumatic flotation the power required to compress the air is the largest single item of expense, and plant layout and porous-bottom construction to reduce frictional head to the minimum should merit closest scrutiny. While canvas or twill remains the favorite, concrete bottoms have given most encouraging results



at Ray Consolidated, while bricks of bakelite and sand, and other porous materials are constantly being tried. In many cases, air pressure can be reduced by using a thin bed of pulp in the flotation machine, the area of the flotation cells may be reduced by judicious intermediate classification, and recoveries may be increased by an efficient primary agitator to mix thoroughly the oil into the pulp. Mixing oil, acid and pulp by an elevator is in general an expensive method, requiring gun-metal buckets, lead-covered pulleys, and a belt renewal after six months.

Tables have by no means vanished, in fact the new Plato table has been given much attention and tried with many different shapes and kinds of riffles. Tables of some sort will be seen in flotation mills for many years to come, roughing high-grade feed and catching coarse mineral in tails.

### Catalyst for the Oxidation of Ammonia

REFERENCE to the article appearing elsewhere in this issue will show that, although the urgent need of adequate catalysts for preparation of nitric acid in the war industries no longer exists, we may, nevertheless, expect the work will be carried on to ultimate perfection, for adaptation to peace-time manufacture. The results of long experimentation carried to partial completion within the last few months have brought to us a wider vision of the large work that is yet to be done. We may well hope for still greater achievements from the scientists both here and abroad in the near future.

The generous manner in which these investigators are making public the conclusions arrived at from their exhaustive research, and the frank and open discussions resulting therefrom, will lead only to the attainment of the true ideal—the greatest benefit to the greatest number in everything that's chemical.

### Efficiency and Morale Of Steel Mill Labor

IT IS a familiar dictum that shortage of labor encourages the introduction of labor-saving machinery. There is a general shortage of labor in the United States now and there will be for several years to come unless capital emigrates in tremendous volume or withdraws very largely from investment. Shortage of labor and abundance of capital are interchangeable terms to a greater extent than is commonly recognized.

In the circumstance of there being a shortage of labor one might be disposed to jump to the conclusion that the chief duty of steel mill managements at this time is to devote their attention to the introduction of additional labor-saving devices. There is ground for argument that this is not the correct deduction from the circumstances. Before the strike of September 22 the production of steel was not equal to the actual capacity of the steel-making units in operation, rating them according to performance in the past, say in the year 1916. There may have been some shortage of labor at that time, in point of numbers, but the common complaint was that labor was not performing efficiently. In the past few weeks the production of steel has been far below what it should have been in proportion to the number of men in employment. It is the

commonly expressed opinion to-day that for some indefinite time to come steel mill labor will be below par in efficiency and morale.

Obviously this is not a condition that can be remedied by the introduction of additional labor-saving machinery. The condition is rather that on account of the human element the machinery is not producing as it is physically capable of producing. The remedy is to be sought not in additional or modified machinery but in a change in the attitude and performance of the workmen in the steel mills.

Since the inception of the strike of last September much has been said of the ignorant foreigner employed in the steel mills, ignorant even of the language. There has been much talk of the necessity of "Americanizing" him. It certainly follows that if steel mill labor in the past has been largely ignorant of the language, and in the future is to be more familiar with it, there is opportunity to arrange that the labor shall in future work more intelligently and efficiently.

The chief problem, then, seems to be not to improve the machinery of the steel mill, but to improve the men's handling of the machinery. It is not a problem of machinery, but a problem of men. In this day of labor shortage steel mill managements should not follow the dictum cited and study machinery and mechanical possibilities, but should study men and the possibilities of enabling them to do better work with the machinery already provided.

It may be that in the past "payment by results" has been carried in steel mills as far as it could be carried with the various descriptions of men that were at work. As many men, perhaps, have been given tonnage jobs as could understand the essence of a tonnage job, the more tons the more pay, and were sufficiently in touch with the management to have confidence that the pay envelope really represented the performance. Even granting that such has been the case, though there is room for doubt whether payment by results has been extended as far as it could be with the conditions of the past, it is clear that if there is to be, as there certainly must be, an increase in the intelligence of the men and a greater ability to understand the foreman or superintendent, a closer touch between the management and the workmen, payment by results can be extended.

Payment by results is not as popular as it should be on theoretical grounds, and one may venture to assert that the principle would be much more popular to-day if in years past so many employers had not abused the thing in practice. Often employers have cheated men directly and have swindled them by offering piece rates which were reduced when the men furnished more of the goods bargained for than had been expected. The main thing wrong with piece work has been the employers. The steel industry has its own principles and morals well established that when it offers piece rates or payment by results it treats its workmen fairly. There have been quarrels on this subject only when the men wanted to treat the management unfairly, when they refused to accept a reduction in tonnage rates when the tonnage increased not by the efforts of the workmen but by the investment of greater capital in improved machinery. The steel industry now has an opportunity to increase labor performance greatly by getting in closer and more intelligent touch with its workmen and by extending the system of payment by results. That is the rational way to improve the efficiency and morale of the men.

## Western Chemical and Metallurgical Field

### Chloride Volatilization Experiments on Ore From Tintic District, Utah

THE chloride volatilization process for the recovery of metals from ores that cannot be economically treated by usual metallurgical methods has received considerable attention during the last few years; there are at present, however, no commercially successful installations in operation in which the recovery of the metals is dependent upon the volatilization of these metals as chlorides. Laboratory investigations have almost invariably indicated that an economical recovery should be possible. In semi-commercial experiments difficulties have been encountered, more particularly with the roasting operation. The recovery of the fume has been successfully accomplished by means of bag-houses or by electrical precipitation, but, again, the treatment of the fume has presented difficulties. The practical solution of the entire problem will undoubtedly come with the development of apparatus designed to carry out the particular metallurgical and chemical reactions. Apparently standardized equipment cannot be modified so as to produce a practical unit that will perform its function in this metallurgical scheme with entire satisfaction.

A great deal of experimental work has been done on an ore from the Tintic district at Eureka, Utah, that has indicated the difficulties encountered, and the practical solution of some of these has been obtained. This is an oxidized siliceous ore containing lead, silver and zinc. It occurs as a replacement in limestone and is of a type which cannot be successfully treated by any developed metallurgical method. The ore is so highly siliceous that a pyrometallurgical treatment is impossible; the high lime content makes a hydrometallurgical method using an acid leaching solution uneconomical unless acid can be made on the plant. The average analysis of the ore is: Insoluble 62 per cent, lime 5 per cent, lead 8 per cent, zinc 2 per cent, silver 15 oz., and gold 0.1 oz. per ton. This ore is too low in lead and too high in silica for direct smelting except perhaps by mixing in limited amounts with a basic ore. It contains about 15 per cent of acid-consuming constituents. The physical characteristics are such that it cannot be successfully concentrated by wet methods or by flotation. These facts led to experimentation in order to determine whether the chloride volatilization method would be practical. A variation in this method as usually conceived was the idea of depending entirely upon the volatilization of the metals as chloride.

The ore was ground to 20 mesh, mixed with 10 per cent by weight of salt and roasted in scorifiers in an assay muffle. As a result of twenty tests on representative ore samples the following approximate volatilizations were obtained: Au 90 per cent, Ag 91 per cent, Pb 87 per cent, Zn 72 per cent. Average analysis of the ore and the calcine follows:

	Oz. per Ton		Per Cent	
	Au	Ag	Pb	Zn
Ore	0.10	8.9	3.92	2.9
Calcine	Trace	0.8	0.52	0.8

Recoveries obtained from similar tests upon representative ore samples from a different part of the mine were Au 80 per cent, Ag 74 per cent, Pb 98 per cent,

Zn 53 per cent, with the following average analysis of the ore and calcine:

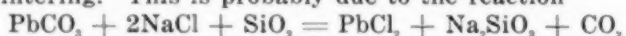
	Oz. per Ton		Per Cent	
	Au	Ag	Pb	Zn
Ore	0.080	20.9	17.3	5.8
Calcine	0.016	5.4	0.4	2.7

Experiments were made to determine the effect of calcium chloride and mixtures of calcium and sodium chloride in various ratios upon the rate and completeness of the volatilization and also the effect of the ratio of the chlorides to the ore. The results of these tests show that where salt is used as the chloridizing agent there is a tendency of the ore to sinter which becomes more noticeable with increasing amounts of lead in the ore. With calcium chloride the tendency to sinter is not as noticeable with the high-lead ores. The best results were obtained when using a mixture of two parts of calcium chloride to one part of salt. Early sintering causes a low volatilization of all the metals.

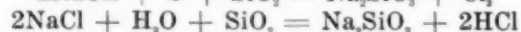
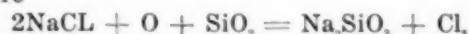
It was found that an oxidizing atmosphere is absolutely essential in order to obtain satisfactory volatilization of the silver. With the lead, volatilization took place as well in a neutral or reducing as in an oxidizing atmosphere. Pure silver chloride alone is practically non-volatile at the temperature maintained in the furnace or at about 850 deg. In the presence of lead chloride and sodium or calcium chloride it is, however, volatile at this temperature. It is claimed that  $\text{AuCl}_3$  is decomposed at about 850 deg. C.; the recovery of gold from the fume indicates that the gold may be volatilized as a complex compound, since it is present in the fume as chloride and as metal. The amount of salt, calcium chloride or mixture of the two that produced the best results was found to be approximately 10 per cent of the weight of the ore. With ores containing 15 to 20 per cent lead this amount should be increased, but in any case the proportion to be used must be determined by experiment. Magnesium chloride acts similarly to calcium chloride.

#### SINTERING

The tendency to sinter increases with the fineness of the grinding and with the amount of lead in the ore. The combination of a high lead content with salt as a chloridizing agent was particularly favorable to sintering. This is probably due to the reaction



Sodium silicate has a melting point below the temperature at which it is necessary to maintain the furnace charge. Other reactions which tend to take place are



This last reaction takes place fairly rapidly, but can be prevented by proper control of the furnace temperature, while the other reactions proceed more slowly. Addition of lime rock tends to prevent sintering at the furnace temperatures, since lime-soda silicates tend to form and with proper control of furnace conditions this reaction does not proceed far enough to produce a viscous slag. If the volatilization roast be preceded by an oxidizing roast, sintering is to a large extent prevented. Obviously, these reactions do not take place where calcium chloride is used. The preceding reactions are given to show the manner in which sodium silicates are formed. Experimental work has shown that silica is not required for volatilization of the metals.

The results obtained from these experiments war-

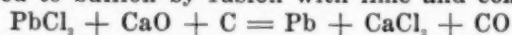


ranted the testing of the process on a semi-commercial scale. A small reverberatory furnace was constructed, but did not prove to be satisfactory in operation. In order to volatilize even half of the silver very active hand rabbling had to be resorted to. This was attributed to the incomplete chloridizing, to the difficulty of maintaining proper temperature and particularly to the impossibility of maintaining an atmosphere duplicating muffle conditions. Further tests were made using a rotary kiln and more encouraging results were obtained; the capacity was, however, too low for commercial application. There was a tendency to form a nose ring at the feed-end of the kiln due to the moisture in the incoming ore. Nose rings at the fire end were formed by overheating of the charge. As the standard kiln is fired only at one end, the best operating temperature could not be attained in all parts of the furnace.

Fume from the kiln was passed through cooling pipes to a bag-house. The temperature was not reduced sufficiently to condense moisture on the bags since as the result of the reaction with zinc chloride, hydrochloric acid would be produced. New bags allowed the escape of fumes but not in sufficient amount to condemn the method. Electrical precipitation has been used to recover a similar fume at the Salt Lake City station of the Bureau of Mines, with practically complete recovery of the fume.

#### TREATMENT OF THE FUME

The fume contains lead, silver and zinc as chlorides, gold as chloride and metal, and in addition sodium and calcium chlorides. If copper were present in the ore, it will also be present in the fume as a chloride. Several methods for the recovery of the metals are possible. Zinc and copper can be removed by leaching with water, this will also remove a portion of the lead. The gold, silver and the remaining lead can then be reduced to bullion by fusion with lime and coke.



This reaction will take place in the absence of silica, which latter if present will cause a re-volatilization of the lead. Copper and any silver or gold that may be extracted by the leaching solution can be precipitated on iron. By this method the chlorine is recovered in a form that can be again used in the volatilizing roast.

If the fume cannot be treated directly in the above manner, it may be leached with hot water, or better with a saturated solution of salt, and the lead recovered by one of several methods. If the solution be concentrated, quite pure  $\text{PbCl}_2$  will crystallize on cooling and the residue can be treated by the fusion method; or this solution can be electrolyzed with soluble iron anodes. Complete precipitation of the metals is possible by boiling with sponge iron. The residue can then be smelted.

Continuation of the investigation with this particular ore and the development plans for a plant to treat the ore by the volatilization method in commercial quantities were temporarily suspended because of the development of ore on the property that was amenable to standard methods of concentration.

Work of a similar nature is being carried on at several experimental plants in the West, and by the Bureau of Mines station at Salt Lake City. Determination of the vapor pressure of silver chloride and investigations of the factors controlling its volatilization at furnace temperatures are now being conducted at the Berkeley station of the Bureau of Mines.

## Meeting of Chicago Section<sup>1</sup>American Chemical Society

AT THE Dec. 19 meeting of the Chicago Section, A. C. S., Dr. Hoskins called to the attention of the Section a circular letter which has been issued from the national secretary's office relative to H.R. Bill No. 8078, known as the Longworth bill. This letter contains a request that each individual member of the American Chemical Society communicate personally with Lawrence Y. Sherman and Medill McCormick, Senators, with the request that they use their efforts to make the bill a law. He also read a letter from Dr. Stieglitz, who is in New York, urging the members to communicate with these Senators. If this bill is not passed within a short time Germany could ship a quantity of vat dyes and organic chemicals sufficient to permanently discourage manufacture in the United States. This condition would be further aggravated by the present exchange rates, as the quotations are in German marks. Dr. Hoskins exhorted the members of the local Section to comply with the secretary's request.

#### WILL LIMIT CHEMICAL IMPORTATIONS

Dr. Redman, chairman, emphasized the fact that this bill will practically prohibit the importation of organic chemicals from *any* foreign country to the United States in all instances where the compound may be obtained in this country at a fair price for a good quality. The bill virtually gives a few years for the development of the industry and covers many chemicals. As these chemicals are also of vital importance in time of war it becomes a national and patriotic measure.

The paper of the evening was "The Business Side of Chemistry," presented by Otto Eisenschiml. His remarks, which are given in part herewith, are well worth the consideration of every man in the chemical and engineering profession.

#### The Business Side of Chemistry; Some Ideas on the Selling of Chemical Knowledge

Our colleges dismiss their graduates with the impression that their earning power will be in direct ratio to knowledge and chemical ability. That is not so. Chemical knowledge must be sold, and in order to bring handsome returns, must be sold cleverly.

I often wonder if our colleges, training men for chemistry without regard of their future prospects, are aware of the heavy moral responsibility that rests on their shoulders.

I do not blame the colleges for not giving courses in salesmanship of chemical knowledge. I doubt if there is anyone in the colleges who is capable of teaching this.

Business courses would not help the matter, as the graduate will learn this soon enough in his contact after graduation. I do blame the colleges, however, for failing to point out to their students that such salesmanship is essential to their progress.

To acquire chemical knowledge and use it for the common good is a worthy idea. There is nothing, however, in the law of the land or in the ethics of the profession to interfere with one's desire to obtain financial independence at fifty. Assuming that most chemists will live their lives in positions, have they not the right to fair recompense? Are we, like the owls in Athens, supposed to live on nothing but our wisdom?

It is reported throughout the country that professional chemists of caliber are taking up business pursuits in order to provide the wherewithal for decent living. If such a movement should take on large proportions it would be alarming and detrimental to the best interests of civilization. This consideration should bring a discussion on compensation for chemical service above the level of general discussions on money matters.

I have been criticized and ridiculed for discussing the possibility of reducing the number of chemists by disseminating facts among students regarding the true earning power of our profession. Is it more desirable to have men of forty quit in disgust and despair than to give a prospective chemist an inside tip on his future business prospect?

A man may decide to sacrifice his life on the altar of science, but he has no right to sacrifice his wife and children likewise.

#### PROBLEM A NATIONAL ONE

The problem is a national one, and I believe it can be corrected through proper publicity. I would not recommend a specific remedy at the first discussion. But the younger chemist should know that he is going to be up against it after leaving college. I believe in holding the number down to a minimum, not by law or regulation, but by previous advice to the undergraduates. The colleges are responsible for flooding the markets.

Most chemists hold good hands and play them like amateurs. Most business men hold nothing but a small pair and take the pot. The graduate starts wrong by accepting too low a salary for his first position. Most employers are willing to allot any salary and leave it to the man to make good. If he starts at \$60 per month, he is forever handicapped. Every chemist who rings a time clock rings his own death knell.

The main thing is to get started right. It is not impossible because of present precedents to get a large salary on the start. If a man can sell shoestrings he can sell chemistry. The trouble with the present graduate is that he does not know how to meet men and market his services. He lacks the knack of salesmanship.

#### LACK OF BUSINESS KNOWLEDGE THE TROUBLE

Next to starting wrong the promotion in existing positions is very hard. Business knowledge is a mystery to the chemist. That's the trouble! It is easy to learn business, because it is just common sense. To sell a chemical formula to a layman is unfair to both buyer and seller. To sell a chemical service together with a formula is good ethics and very good business. A chemist that does not know the market value of every ingredient he handles is a failure. He can never expect to be more than a servant of industry.

Nothing is gained by the everlasting wail that chemistry is an underpaid profession. The law of supply and demand listens to no moral arguments, no matter how plausible. A laboratory chemist is generally paid merely for collecting facts, and he can expect no high pay for this service. The man that correlates these data and draws the business conclusions is the one that reaps the harvest. Chemists often furnish advice to business men on which the business men make one hundred times the amount of the fee. It is peculiar that so few chemists are willing to take the risk of financing their own devices.

I suggest only individual changes and no revolutionary movement. There is no reason why one brain cannot hold both common sense and applied chemistry.

#### Discussion

The paper was very heartily received by the Section and a number of approving speeches followed. Mr. McCoy stated that Mr. Eisenschiml's remarks were excellent and to the point. It is a question of salesmanship and also service to the employer. He must show the manufacturer that he is bringing returns to the company.

Dr. Wesson, who has recently been elected president of the American Institute of Chemical Engineers, stated that if he could have met Dr. Eisenschiml twenty-five years ago it would have been money in his pocket. The chemist must demonstrate to future employers that he is an asset rather than a liability.

Mr. Williams voiced the sentiments of Mr. Eisenschiml. He stated that an engineering course and chemical course are the same in that they lead to anything if you quit soon enough.

#### New Jersey Clay Workers Hold Annual Meeting

The annual meeting of the New Jersey Clay Workers' Association and Eastern Section of the American Ceramic Society has grown to be one of the important events of the year in ceramic circles in this section, and the gathering at New Brunswick, N. J., on Dec. 18 emphasized this impression. Close to seventy members and guests were present at the morning and afternoon sessions, held in the Fine Arts Room, Queens Building, Rutgers College.

The morning session was given over to general business and the presentation of two papers, the first an impressive talk by Charles Howell Cook, president of the Cook Pottery Co., Trenton, N. J., and chairman of the association during the past year, on the subject of "Preparing for Future Competition." He set forth the urgent necessity for the American manufacturer to be watchful of the inroads being made in the importation of ceramic and other wares to this country from England, Germany, Japan, China and other countries. He gave an interesting piece of information that a ceramic school was now operative in China, with a Japanese, educated in the United States, as director.

The other paper was an instructive lecture by Homer F. Staley, Bureau of Standards, Washington, D. C., on "Feldspar as a Pottery Material." The paper covered the composition of pure feldspars, their geological occurrence, winning and preparation, grading and chemical analyses. Reference was made also to the mineral composition of well-known feldspars, and methods of testing and blending. In a summary of the subject, substitutes for this material in pottery production were mentioned, including the most popular, Cornwall stone, white mica and talc.

The afternoon meeting, coming to order after an enjoyable luncheon at the Hotel Kline, was devoted to a broad discussion of fuel. Three important papers on this subject were presented, "Fuel Analyses," by A. C. Fieldner, supervising chemist, Bureau of Mines Experiment Station, Pittsburgh, Pa.; "Oil Burning in a Ceramic Plant," by R. L. Clare, Federal Terra Cotta Co., Woodbridge, N. J.; and "A New Type of Producer-Gas Fire Box," by R. H. Minton, General Ceramics Co., Metuchen, N. J.



Mr. Fieldner's paper was a comprehensive résumé of methods in use for analyzing coal, covering sampling, proximate analysis, ultimate analysis, determination of heating value, fusibility of ash and a survey of the fusibility of ash of American coals. Information was also given regarding a calculation of heating value and ultimate analysis from moisture and ash determination.

Other papers given at the afternoon meeting were "Properties of Pottery Bodies and Glazes," by H. G. Schurecht, Bureau of Mines, Mining Experiment station, Columbus, Ohio, and the "Furnace Gas Producer," by Charles W. Parks, ceramic engineer, International Clay Machinery Co., Dayton, Ohio. Mr. Schurecht's paper was a technical treatise on pottery bodies, embracing such data as elutriation tests on kaolins, the effect of electrolytes, grinding, screening and organic additions on bodies, refractories, coefficient of expansion of bodies, crazing of glazes with special reference to coefficient of expansion, luster decorations for pottery and aventurine glazes.

At the annual election of officers, the following were appointed for the coming year: Abel Hansen, head of the Fords Porcelain Works, Perth Amboy, N. J., chairman; C. S. Maddock, Jr., of the Thomas Maddock's Sons Co., Trenton, N. J., vice-chairman; Charles A. Bloomfield, head of the Bloomfield Clay Co., Metuchen, N. J., counselor; Charles Howell Cook, Trenton, chairman of executive committee; and George H. Brown, director, department of ceramics, Rutgers College, New Brunswick, secretary and treasurer.

#### Officers of the Iowa Section, A. C. S.

The officers of the Iowa Section of the American Chemical Society for the coming year have been elected as follows: President, W. S. Hendrixson, Grinnell, Iowa; vice-president, P. A. Bond, Iowa City; counselor, R. M. McKenzie, Fairfield; secretary-treasurer, F. S. Mortimer, Iowa City.

#### American Metal Buys Vogelstein

The American Metal Co. has acquired the entire business of L. Vogelstein & Co. The purchase gives the American Metal Co., which has heretofore been mainly interested in zinc, lead and minor metals, a prominent place in the copper market, as the business of L. Vogelstein & Co. was mainly done in this metal.

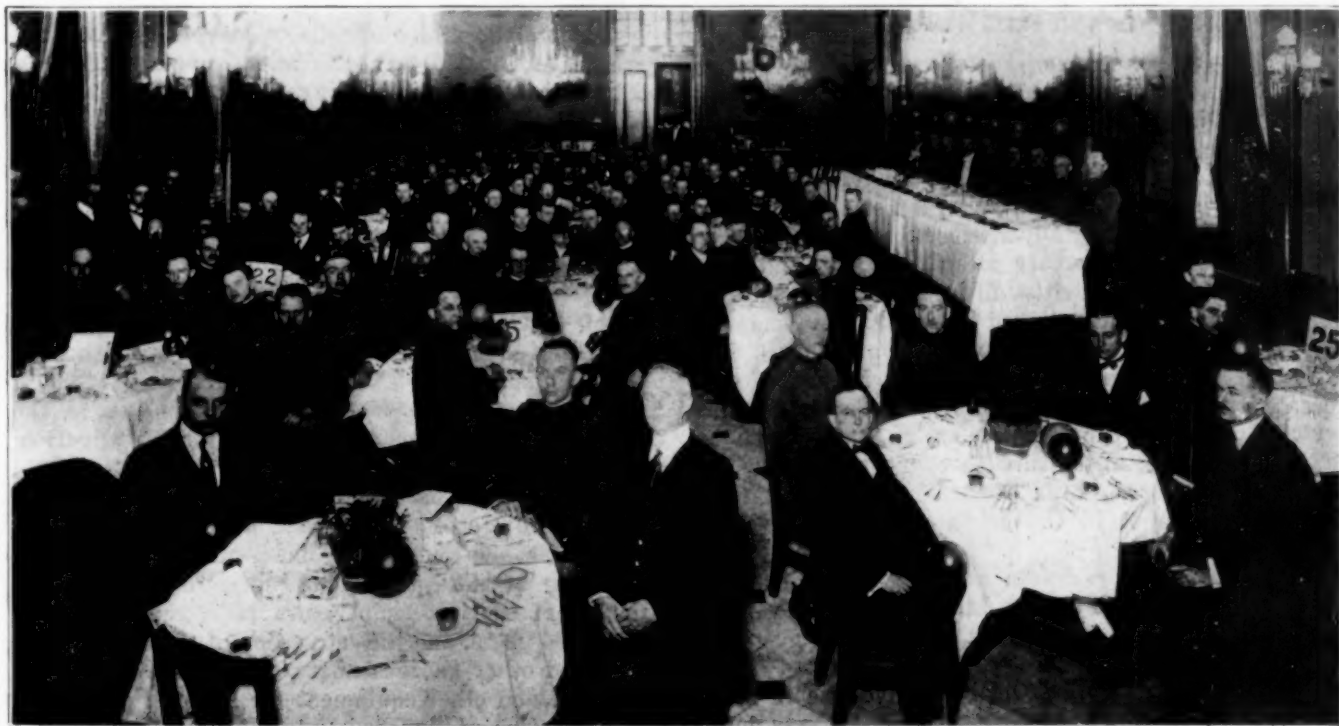
Among the assets of the Vogelstein company taken over by the American Metal Co. is the copper refinery at Chrome, N. J., in which Vogelstein up to recently had a minority interest. He now has the controlling interest by purchase from the United States Smelting, Refining & Mining Co.

Mr. Vogelstein acquired a substantial interest in the American Metal Co. at the recent sale of metal company shares held by the Alien Property Custodian. Other purchasers of shares at the same time were the Cerro de Pasco Copper Co., J. Horace Harding, Louis T. Haggin, Charles D. Barney & Co. and others affiliated with the Cerro de Pasco Co.

#### Annual Dinner of the Chemical Warfare Service

The second annual dinner of the Chemical Warfare Service was held at the New Ebbitt Hotel, Washington, D. C., Friday, Jan. 2, 1920. The dining room was appropriately decorated with small colored balloons filled with hydrogen and attached to each plate. About 150 officers and ex-officers of the service were present.

Members of the service took advantage of the occasion to express their appreciation of Major-General Sibert, director of the Chemical Warfare Service, through the presentation of a large reading lamp of unusual design. The base was of carved wood, while the standard was a 75-mm. gas shell, with a cluster of lamps at the top. Lieutenant-Colonel Amos A. Fries presided as toastmaster; responses were made by Major Brown, Colonel Ellicott, Major Woods, Major Sutherland, General Sibert and H. C. Parmelee. Major H. S. Kimberly was chairman of the general committee.



ANNUAL DINNER CHEMICAL WARFARE SERVICE, WASHINGTON, D. C., JAN. 2, 1920

## British Chemical Industry

(From our London correspondent)

**I**NDUSTRIAL conditions seem to be becoming more stable as the international labor situations are taking more definite shape, although the change over from war to peace programs created uncertainty, especially among the smaller firms. The export trade continues to be very active and the home trade is also improving. The American coal strike has naturally contributed to this. The need of increased capital to meet new conditions is illustrated by the great increase in new capital issues. The formation of trade associations still continues, while among the manufacturers of chemicals considerable activity is being shown in new types of plant and apparatus, some of which originate in the United States and for which catalogues and advertisements are issued at frequent intervals. Standardization of plant, detail fittings, and even of pipework and stoneware is still conspicuous by its absence. The coal situation continues to be interesting and if, as is probable, the price can be reduced, this will give a considerable stimulus to the chemical industry.

### TWO VALUABLE REPORTS

In the industrial field interest has centered on the report recently issued by the **Factories Branch** of the Department of Explosives Supply and on the somewhat overdue final report of the **Nitrogen Products Committee**. The former gives valuable information on factory records and cost systems presented in such a way that the individual manufacturer can adapt them to his own requirements. The latter will be published shortly and comprises several hundred pages of carefully compiled information and data covering the whole nitrogen field and making all necessary recommendations regarding the future requirements of the British Empire. The general nitrogen situation has been ably reviewed in the technical press by Dr. Maxted and a decision must soon be made in regard to the future of the Haber and cyanamide processes.

### GOVERNMENT TO SELL NITRATE PLANT

It is, of course, common knowledge that the British Government had started to build a Haber nitrate plant at Billingham-on-Tees, Yorkshire, and that when work ceased there soon after the armistice, the buildings had not progressed much further than their foundations, though a good deal of plant was on the site or on order. The government now by advertisement invites offers for the purchase of the factory at private sale, and it is known that a leading British firm, probably in conjunction with firms having linked interests, has made an offer. As it has just been officially announced that licenses have been granted to Brunner, Mond & Co. to operate certain Badische and Haber patents, it seems certain that this is the firm in question, particularly as the necessary capital is available owing to the sale for cash to Lever Bros., Ltd., of Brunner, Mond & Co.'s controlling interest in Crosfield's and Gossage's soap works.

As regards dyes, licenses have just been granted to Morton Sundour Fabrics, Ltd., to operate various patents of the Badische, Bayer, Griesheim and other German dyeworks.

The anti-dumping bill is likely to give rise to much controversy and is viewed with considerable misgiving in some quarters.

The new president of the Society of Chemical Industry, John Gray, of Lever Bros., Ltd., seems to be infusing new life and increased vigor into its activities. The new Chemical Engineering Group already comprises nearly 700 members and is to hold conferences and symposiums on appliances for moving liquids, and on labor-saving devices in chemical works, at Newcastle and Birmingham respectively. For the latter, American specialties will no doubt predominate, and owing to the increased cost of labor, there should be an active demand for them among British manufacturers. Turning to the social side, which has been sadly neglected over here in the past, the Chemical Industry Club is playing an important part and the recent first annual dinner of the club, which now has over 700 members, was a notable occasion. Reciprocal membership has been arranged with the Chemists' Club of New York and many Americans have already made use of the facilities offered.

Dr. J. Gordon Parker has been elected president of the International Association of Leather Trades Chemists, the next conference of which will be held in London in 1921. A new chair of applied physics is to be founded at Glasgow University, while courses and lectures in chemical engineering are being arranged at many universities and technical colleges.

The Shawinigan Co. of Canada has founded a branch company, Shawinigan, Ltd., at 1 Tudor St., London, E. C., 4, for the sale of its products.

### Bureau of Standards Plans Increase in Chemical Activities

Congress has been asked for nearly \$3,000,000 to carry out the program of the Bureau of Standards during the next fiscal year. The plan includes the expansion of many of the chemical activities of the Bureau. The items of interest to chemists are as follows: For testing chemicals, varnishes, soap materials and inks, \$50,000 (an increase of \$20,000 over the current appropriation); to study methods of measurements and technical processes used in the manufacture of pottery, brick, tile and other clay products, \$50,000 (an increase of \$30,000); to determine experimentally important physical constants of materials essential to the industries or in laboratory investigation, such as the determination of the value of gravity, thermal conductivities of material, mechanical equivalent of heat, metallurgical constants (such as specific and latent heats of metals and alloys), the electrochemical equivalent of metals, and the velocity of light, \$25,000 (an increase of \$20,000); for purchase, preparation, analysis and distribution of standard materials to be used in checking chemical analyses and in testing of physical measuring apparatus, \$15,000 (an increase of \$10,000); for the investigation of the problem involved in the electrodeposition of metals, \$20,000; for investigation, aiming at improvement in the quality of reagents used in chemical analysis and their eventual standardization, \$15,000; for the equipment, maintenance and operation of a low temperature laboratory, including the production of extremely low temperatures, the establishment of the low temperature scale, the production of liquefied gases, and the separation of the constituents of air and other gaseous mixtures, the development of containers and other equipment for liquefied gases, and the application of liquefied gases and low temperature investigations to aviation, \$20,000.



# Inaccuracy of Treating Records Due to Moisture in Wood

Description of the Experimental Work to Determine the Reactions Taking Place in the Treatment of Wood With Inorganic Salt Preservatives — Record of Tests, Discussion of the Results and Conclusions

By ERNEST BATEMAN\*

IN STUDYING the effect of leaching on wood treated with inorganic salt preservatives, such as zinc chloride, copper sulphate, zinc sulphate, cresol-calcium, etc., it has frequently been noticed that the treating record did not check at all closely with the amount of salt found to be present in the wood. The treating record consisted in the weight of the piece before and after treatment, the difference between the two being considered as the amount of solution injected. This weight of solution multiplied by the per cent of concentration should give the amount of salt injected into the piece. Analysis of the wood after treatment frequently showed that there was often as much as 50 per cent more salt actually in the piece than the treating record showed should be the case and rarely if ever did the record and the analysis agree. In commercial practice the same phenomenon was noticed to a greater or less degree. The theory which has been advanced by wood preservers that there is a chemical union between zinc chloride and wood substance seems therefore to have some basis for its existence. If this is the case, then we must also attribute the increased absorption of such salts as zinc sulphate, copper sulphate, cresol-calcium, and, as will be shown in this paper, calcium chloride, to the same cause.

## EXPERIMENTAL DETERMINATION OF WOOD ABSORPTION OF INORGANIC SALT PRESERVATIVES

In order to throw some light on the subject small pieces of wood 2 x 2 x 8 in. were treated with zinc chloride solution and the solutions analyzed before and after treatment to determine if there was any change in the strength of solution. The amount of wood used was as great in proportion to the solution as it was possible to make it. Three conditions of wood were used, oven dry, air dry, and green. The analysis of the solutions showed that there was a change in the strength of solution during treatment, but the weakening of the solution was not in proportion to the amount of wood present in the three runs, and in one case no weakening at all was obtained. The results were such that no very definite conclusion could be drawn. It was therefore decided to make a much more comprehensive and detailed study of the treatment, but in place of zinc chloride to use calcium chloride, chiefly because calcium is much more readily and accurately determined than zinc and at the same time it resembles zinc chloride in its solubility, deliquescence, etc. A small treating cylinder was used, and here again, as in the previous case, the amount of wood was made as large as possible in comparison with the treating solution. The weighed wood was treated to refusal at a temperature of 180 deg. F. Three conditions of

wood were again used, oven dry, air dry, and green; the first containing no moisture, the second 15 to 20 per cent, while the third had 30 per cent or more. Actual moisture determinations were not made. The solution was weighed before and after treatment, separate solution being used for each run. As soon after treatment as possible the wood was removed from the treating cylinder and placed in covered glass jars to drip and cool. These were then weighed after cooling. The difference in weight before treatment and the weight after treatment and cooling was taken as the treating record. The drip and condensate were also weighed.

The wood was allowed to dry to some extent and was then reduced to sawdust and analyzed for calcium. The method of analysis consisted in ashing a weighed portion of sawdust and determining the calcium volumetrically by means of its oxalate. The accompanying tables show the results obtained.

TABLE I. TREATING RECORDS

	Run 1			Run 2			Run 3		
	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb.
Wt. solution before treatment.....		21.90			21.60			20.90	
Wt. solution after treatment.....			16.53		16.07				15.77
Wt. of wood after treatment.....	8.68			8.63			7.80		
Wt. of wood before treatment.....	4.09			4.80			5.29		
Absorption of sol. (by difference).....			4.59			3.83			2.51
Drip.....			0.58			1.12			1.48
Loss by leakage or evaporation.....			0.20			0.58			1.14
		21.90	21.90		21.60	21.60		20.90	20.90

TABLE II. ANALYTICAL RECORD

	Run No. 1		Run No. 2		Run No. 3	
	Strength Per Cent	Total Salt	Strength Per Cent	Total Salt	Strength Per Cent	Total Salt
Solution before treatment.....	1.84	0.4030	1.41	0.3046	1.79	0.3741
Solution after treatment.....	1.84	0.3042	1.35	0.2169	1.78	0.2806
Drip.....	1.35	0.0078	1.37	0.0152	1.61	0.0239
Found in wood.....		0.0873		0.0700		0.0695
Loss by difference.....		0.0037		0.0025		0.0000

## CORRECTION OF RESULTS

Although an attempt was made in this work to reduce the losses of both solutions and salt to as small a factor as possible, in spite of these precautions small losses did occur. It is almost impossible to pump 20 lb. of solution from a carboy to a treating cylinder, put it under pressure, heat it to 180 deg. F., then after the completion of treatment release the pressure and catch all the solution, and entirely prevent evaporation either from the wood or solution or both. For this reason a complete audit of the solution and salt was made so that these discrepancies could be corrected.

The discrepancies which appear in this work must

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always be errors on the loss side and can be divided into two kinds:

1. Losses due to leaks and to transferring the solution,
2. Losses due to the evaporation of the solution because of its elevated temperature after treatment.

The former would cause a loss in both water and salt, the latter a loss of water only. Whenever we find that we have lost both water and salt in the same proportions, we are justified in assuming that this loss was due to a leak, and when we find that there was no loss of salt but a loss of water, we are justified in assuming that this loss was due entirely to evaporation either from the wood or from the solution. Where we have losses in both water and salt, but they do not check, then we can say that the loss of salt was due to leaks, while the loss of water in excess of this loss by leakage was due to evaporation.

#### RECORDS OF RUN NO. 1

The amount of solution before treatment was 21.9 lb. That accounted for after treatment was 21.7 lb., or a loss of 0.2 lb. The total amount of salt used was 0.4030 lb.; accounted for after treatment 0.3993 lb., or a loss of 0.0037 lb. The concentration of the solution before and after treatment was 1.84 per cent. A loss of 0.20 lb. by leakage would account for 0.0037 lb. of

TABLE III. CORRECTED RECORDS OF RUN NO. 1

	Lb.	Lb.	Lb.
Wt. of sol. before treatment.....		21.70	
Wt. of sol. after treatment.....			16.53
Wt. of wood after treatment.....	8.83		
Wt. of wood before treatment.....	4.09		
Absorption of sol. by wood.....			4.74
Drip.....			0.43
		21.70	21.70
	Strength, Per Cent	Total Salt	
Solution before treatment.....	1.84	0.3993	0.3042
Solution after treatment.....	1.84		0.0078
Drip.....	1.84		0.0873
Found in wood.....			
		0.3993	0.3993

Salt in wood calculating from corrected treating record, 0.0872 lb.  
Salt in wood found by analysis, 0.0873 lb.

salt, or the actual loss found by experiment. We can therefore conclude that there was a small leak in the apparatus, which passed unnoticed during the run.

There was no change in the strength of the solution during treatment, nevertheless the drip solution is noticeably weaker than either of the solutions. At the same time there is more calcium chloride in the stick than ought to have been there if the treating record is correct. The sticks, after removal from the treating cylinder, were placed while still hot under a bell jar to drip. The steam arising from the wood condensed on the jar and ran down into the drip solution with a consequent weakening of this solution. The amount of this condensate can easily be calculated. The record shows 0.58 lb. of 1.35 per cent solution as drip. The weight of this solution must therefore have been increased by the amount of water necessary to dilute a 1.84 per cent solution to 1.35 per cent or

$$\frac{1.35}{1.84} \times 0.58 = 0.425$$

That is, the actual drip was 0.43 lb., the remaining 0.15 lb. being moisture which evaporated from the wood

during cooling. This should be added to the treating record as being absorbed by the wood. The corrected record then reads as in Table III.

#### RECORDS OF RUN 3

In this run there was a loss of 0.89 lb. solution but no loss of salt. All the loss must therefore have been due to evaporation. This may have taken place from the wood or from the solution. It does not seem likely in this run that much of this loss could have

TABLE IV—CORRECTED RECORDS OF RUN NO. 3.

	Lb.	Lb.	Lb.
Wt. of solution before treatment.....		20.90	
Wt. of solution after treatment.....	7.87		16.91
Wt. of wood after treatment.....	5.29		
Wt. of wood before treatment.....			2.58
Wt. of drip solution.....			1.41
		20.90	20.90
	Strength, Per Cent	Total Salt	
Solution before treatment.....	1.79	0.3741	0.2806
Solution after treatment.....	1.66		0.0239
Drip solution.....	1.66		0.0695
Found in wood.....			
			0.3740
Salt in wood from treating record.....			0.0462
Salt in wood from analyses.....			0.0695
Difference excess over treating record.....			0.0233

taken place from the wood because of the short time exposed after treatment. It is known, however, that the stopper was left out of the carboy for some time after the hot solution had been put into it, so it seems likely that the loss occurred at this place. If it all took place here, then the treating record of the solution after treating should be 16.91 lb. instead of 15.77, and the concentration should be 1.66 instead of 1.78. Here again the drip solution is weaker than the solution after treatment and if we follow the same line of reasoning

we can correct this  $\frac{1.61}{1.69} \times 1.48 = 1.41$ . Actual drip  $1.48 - 1.41 = 0.07$  due to evaporation. The corrected record then reads as in Table IV.

#### RECORDS OF RUN NO. 2

In this run we have both a loss of salt and a loss of solution. The loss of salt amounted to 0.0025 lb. or 0.18 lb. of 1.41 per cent solution. The remaining loss, 0.40 lb., must have been evaporation. It seems more than likely that most of this evaporation took place

TABLE V. CORRECTED RECORDS OF RUN NO. 2

	Lb.	Lb.	Lb.
Wt. of solution before treatment.....		21.42	
Wt. of solution after treatment.....			16.07
Wt. of wood after treatment.....	9.01		
Wt. of wood before treatment.....	4.80		
Wt. of solution absorbed.....			4.21
Drip.....			1.14
		21.42	21.42
	Strength, Per Cent	Total Salt	
Solution before treatment.....	1.41	0.3020	0.2169
Solution after treatment.....	1.35		0.0152
Drip.....	1.35		0.0700
Found in wood.....			
		0.3020	0.3021
Salt in wood from treating record.....			0.0594
Salt in wood by analysis.....			0.0700
Excess over treating record.....			0.0106



from the wood itself, because in treating the pieces became wedged in the small cylinder and considerable difficulty was experienced in removing them. Furthermore, the concentration of the drip is greater than that of the solution after treatment. This could only be obtained by evaporation of moisture from the wood and a consequent removal of the more concentrated solution by washing with the drip. This would of course take place chiefly at the ends and would account for only a small part of the actual loss, since the concentrated solution caused by evaporation from the sides would not be removed by the drip. We are therefore justified in assuming that the loss by evaporation took place chiefly from the wood. On this basis the corrected treating records are as shown in Table V.

#### DISCUSSION OF RESULTS

Table VI summarizes all the important corrected data in the three runs.

TABLE VI. SUMMARY OF CORRECTED DATA

	Oven Dry	Air Dry	Green
Wt. of wood, lb.	4.09	4.80	5.29
Amount of solution used, lb.	21.70	21.42	20.90
Strength of solution before treatment, per cent.	1.84	1.41	1.79
Strength of solution after treatment, per cent.	1.84	1.35	1.66
Change in strength of solution due to treatment, per cent.	0.00	0.06	0.13
Amount of salt injected:			
By analyses of wood.	0.0873	0.0700	0.0695
By treating record.	0.0872	0.0594	0.0462
Excess injected over T. R.	0.0001	0.0106	0.0233

In only one of these conditions does the treating record agree with the amount found by analysis, that is, the oven dry pieces. In this also the strength of the solution remained unchanged as a result of treatment. If there is any change in the concentration due to chemical affinity it ought also to be shown in this as well as in the two other cases. We can therefore discard the theory that the wood substances enter into a firm chemical union with the materials used in treating.

There is, however, a striking relation between the reduction in concentration of the treating solution, the apparent excess absorption of salt and the moisture content of the wood. With an increasing moisture content of the wood, the difference in concentration of the solutions before and after increases, and the excess salt found in the wood increases.

This leads to the conclusion that the moisture present in the wood acts as if it had actually been added to the solution and decreases its strength. In other words, the water present in the wood is replaced by solution. This solution would then escape measurement because an equal amount of water takes its place. The amounts of water necessary to cause the reduction in strength for the two solutions are respectively 0.85 lb. and 1.69 lb. Unfortunately, moisture determinations were not made, but the treatments were made with the same number of pieces of approximately the same dimension and same species, consequently the oven dry weight of all three runs should be approximately the same. We should be able to form some idea as to whether or not there could be present in the wood sufficient moisture to cause the phenomena noted. If we take the oven dry sticks as a basis of oven dry weight, we find that there was at least 0.71 lb. water in the air dry stick and 1.20 lb. water in the green stick, so that it is not unreasonable to suppose that the difference between these weights and that required may be due to shrinkage of wood, differences in density

of wood substance, and differences in the size of the pieces. If we then subtract the amount of water required to dilute the solutions from the green weight of the wood before treatment, we should get the dry weight of the wood.

$$\begin{aligned} 4.80 - 0.85 &= 3.95 \text{ lb.} \\ 5.29 - 1.64 &= 3.65 \text{ lb.} \end{aligned}$$

Subtracting these weights from the weight after treatment should give us the amount of diluted solution injected into the wood.

Run No. 2	Run No. 3
9.01	7.87
3.95	3.65
5.06 of 1.35 per cent	4.22 lb. of 1.66 per cent sol.

on a salt absorption of 0.0684 and 0.0701 respectively, actually found by analysis being 0.0700 and 0.0695 respectively. From this it would seem that the correct explanation of the phenomena noted is that the water in the wood acts as a diluent of the treating solution and gives a greater treatment than is apparent from the treating record.

#### CONCLUSIONS

The following conclusions can be drawn from this work:

- There is no apparent reason to suppose that a chemical combination results from the treatment of wood with most inorganic salts, such as zinc chloride, zinc sulphate, sodium fluoride, calcium chloride, etc.
- The moisture present in the wood at the time of treatment acts as diluent of the solution.
- Any system of measuring the absorption of salt by wood during treatment which is based on a measurement of the weight or volume of the solution before and after treatment is liable to a very considerable error. Only when the wood is free from moisture are such measurements exact. At all other times either weight or volume measurements will be in error because of the exchange of the moisture in the wood for solution so that more solution will actually be injected than is made apparent from the treating records.

#### Action of Muriatic Acid on Manila Rope \*

At the instigation of the National Safety Council, an investigation has been undertaken by the Bureau of Standards, Department of Commerce, to determine the action of muriatic acid on manila rope. The effect of this acid or its fumes on rope of this kind is a great menace, as the acid weakens the rope seriously without any superficial trace of the action being noticeable to the eye. When rope is exposed to this acid, as, for instance, when it is used in blocks and falls of swinging staging when washing down brickwork, etc., many serious accidents have resulted, some of which have been fatal, owing to the fact that the rope has been weakened through contact with this acid or its fumes. The only practical remedy suggested is that of treatment of manila rope before using with some acid-resisting compound. An attempt will be made in this investigation to determine by testing the actual effect of the acid, and ascertain if the deterioration can be remedied by impregnating the rope with a certain compound which the National Safety Council advances as having been effective in protecting machinery and equipment from acid corrosion.

## Present Status and Outlook of the Magnesium Industry

BY J. T. ROONEY, D.S.C.  
Metallurgist, Norton Laboratories, Inc.

**M**ANUFACTURE of metallic magnesium is one of those industries which owes its development in this country to conditions brought about by the war. The metal was first produced in England by Davy in 1808, but it was not until the early '60s that attempts were made to produce it on a commercial scale. In recent times, before the outbreak of the war, plants in England and particularly Germany supplied the world's demand for the metal. It was turned out chiefly in powdered form for photographic flashlights, pyrotechnical purposes, and to a small extent in ingot form as a deoxidizer of non-ferrous metals and for use in light alloys of aluminum.

Prior to 1914 the demand for magnesium in the United States was not sufficiently great to stimulate the production of the metal in this country, but the outbreak of hostilities in Europe, the cutting off of the supply from Germany, and the urgent requirements of the allied governments for the metal for military purposes, with consequent alluring prices, induced several firms to undertake its domestic production.

Plants were erected by the American Magnesium Corporation at Niagara Falls, N. Y.; by the Rumford Metal Co., at Rumford, Me.; by the General Electric Co., at Schenectady, N. Y.; by the Dow Chemical Co., at Midland, Mich.; and by the Norton Laboratories, Inc., at Lockport, N. Y., resulting in the production in 1915 of 87,500 lb., in 1916 of 75,400 lb., in 1917 of 115,813 lb.; and in 1918 of 284,188 lb.

Some of these plants closed down after a short period of operation, and practically all ceased production with the sudden termination of the demand when the armistice was signed, and unless new and extensive uses are found for the metal in the near future, most of these plants are destined for the scrap heap.

### PREPARATION OF THE METAL

Magnesium has been prepared by a great variety of processes, i.e., reduction of the oxide with potassium, or with carbon at high temperatures; electrolysis of aqueous solutions of the salts; and electrolysis of the fused salts (usually the chloride) in admixture with salts of the alkalis or alkaline earths.

The method most generally in use and probably the most successful so far has been the electrolysis of fused magnesium chloride with the chlorides of potassium, sodium or calcium, but the scarcity of potash during the war precluded its use and compelled the substitution of other salts.

When the domestic production of the metal was undertaken, the only data obtainable on the subject were a few vague statements in textbooks, each prospective producer being compelled to work out his own method of manufacture independently, and consequently each process differed considerably in detail from the others, while some entirely new ones were developed. Still, the cost of producing the metal appears to have been about the same in all instances.

There can be little doubt that if the knowledge gained at the various plants by experience of the past

few years was pooled, a much more efficient process could be evolved from the combined data than any heretofore existing and the prospect for a greater production of magnesium in the future would be considerably brightened, for while the metal continues to be sold at its present price its application to industry must necessarily be limited.

A favorable factor in the chloride electrolysis process is the possible utilization of the chlorine gas generated at the anodes for the manufacture of by-products, the value of which might materially offset the cost of production of the metal. The simultaneous manufacture of magnesium chloride and potassium chlorate by chlorination of magnesium oxide with waste furnace gases has, in the writer's experience, worked very satisfactorily.

In 1881 von Putner patented a process for obtaining magnesium by reduction of the oxide with carbonaceous matter and a little iron oxide in closed iron retorts heated to whiteness, the vaporized metal passing over into condensers, the process closely resembling the smelting of zinc. Reduction of the metal in this manner is possible because of the more unstable nature of magnesium carbide, which, unlike that of calcium, decomposes at such temperatures. The high cost and difficulty of obtaining the necessary heat were at that time the deterrents to the success of von Putner's method, but today with the ease and economy with which very high temperatures can be obtained by means of the electric furnace, adaptations readily come to mind which should give the process promising possibilities under modern conditions.

### OCCURRENCE OF THE ORES

Magnesium is said to form 2.24 per cent of the crust of the earth and the occurrence of its compounds are almost universal. Great deposits of dolomite, the double carbonate of calcium and magnesium, are very common. Magnesite, or magnesium carbonate, is mined extensively in Hungary, Greece, Canada, and in this country in California and Washington. Enormous quantities of carnallite, kieserite, and other magnesium minerals are available in the great salt beds of Strassfurt, Germany, and may possibly be found also in the deposits in Alsace.

### PROPERTIES OF THE METAL

Magnesium has a greater affinity for oxygen than any of the common metals and combines very readily with it at high temperatures. Advantage is taken of this by employing it as a deoxidizer of metals in the foundry. When magnesium is finely divided it will, after ignition, burn with great violence, emitting a brilliant light rich in actinic rays, and is therefore much used for photographic flashlights and pyrotechnical purposes. These uses are likely to maintain a steady although limited demand for the metal.

Some of the more important physical properties of magnesium in comparison with those of aluminum and copper are given in the following table:

	Magnesium	Aluminum	Copper
Specific gravity.....	1.74	2.7	8.9
Melting point, deg. C..	651	658	1054
Boiling point, deg. C..	1120	1800	2310
Electrical resistivity, m.c./cc. ....	4.35	2.8	1.58
Thermal conductivity	0.376	0.48	1.0405
Coeff. of expansion...	.0000259	.0000222	.0000159
Tensile strength (cast), lb. ....	20,000	15,000	24,000
Elongation, per cent.	9	3	6



At temperatures around 450 deg. C., magnesium can be drawn, rolled, hammered or extruded with comparative ease.

Of course, the properties for which magnesium is chiefly valued as a metal are its low specific gravity and comparative strength, which properties appeal strongly to the modern engineering tendency to lightness in construction, particularly in the case of motor vehicles and aircraft. It is also a very superior bearing metal and has been shown to wear less than even cast iron under similar conditions of test. It machines beautifully, it being possible to cut the finest and sharpest of screw threads with ease and precision, and it is probable that the metal is superior to any other in this respect.

Magnesium, however, also possesses properties which are generally considered as disadvantageous to a metal under certain conditions. Dampness affects the metal, at least superficially; it is attacked by hot or saline waters; it is rapidly corroded by weak mineral or organic acids; and its soft nature renders it easily liable to injury by mechanical abrasion.

The high coefficient of expansion of magnesium may present a serious problem when the metal is used in assembly with other metals which are affected to a considerably lesser degree by varying temperature conditions.

#### ALLOYS

So-called aluminum-magnesium alloys have recently come into use, the magnesium contents of which are less than 1 per cent. It is altogether likely that the magnesium used in casting the metal is of greater value as a scavenger than by virtue of any properties imparted to the alloy by the amount retained.

Magnesium has been cast in aluminum in amounts up to 8 per cent, and some very excellent alloys of low specific gravity and great strength have been produced.

Magnesium alloys readily with practically all of the non-ferrous metals, but when the magnesium content exceeds 10 per cent, the binary alloys become, as a rule, brittle. Similarly, when another metal is alloyed with magnesium in amounts exceeding 10 per cent, these alloys also tend to become brittle.

In the development of useful alloys having magnesium as the predominating constituent, there is plenty of opportunity for research. The pure metal is rather difficult to cast, owing to the tendency to oxidation with inclusion of oxidized particles and because of excessive shrinkage. Binary alloys, generally, present the same difficulties as the virgin metal. But when two or more metals are alloyed with magnesium in lesser amounts, the shrinkage, as a rule, becomes very appreciably less, the hardness is increased, the elongation greatly reduced, the crystalline structure becomes very fine, and well-defined castings can be easily produced quite free from oxides or impurities.

Castings of motor pistons, connecting rods, and like parts have been made of magnesium alloyed with small amounts of other metals, and have given as satisfactory service as those of aluminum, with the added advantage of a considerable reduction in weight. As already pointed out, these alloys retain some of the defects as well as the virtues of the predominating constituent and in the case of motor pistons the high coefficient of expansion characteristic of aluminum and magnesium

necessitates finishing the pistons considerably smaller in diameter than the inside of the cast-iron cylinders in order to avoid jamming by the greater expansion of the pistons when the parts are heated to operating temperatures. Thus, when the parts are cold, there is a clearance between the piston and cylinder which results in a loss in compression and sometimes difficulty in starting the motor. However, this is a condition which could possibly be alleviated by special design of the piston and rings.

The possibilities in the development of magnesium alloys of remarkable lightness and strength, together with the extensive occurrence of the ores, should offer every encouragement to metallurgists throughout the world for the evolution of a process for the production of the metal at a cost which would insure its application to industry on a scale commensurate with its admirable properties.

Lockport, N. Y.

## Economies of Electric Iron and Steel Production in Scandinavia\*

BY JOSEPH W. RICHARDS

DURING a tour of Scandinavia this summer I was particularly interested in inspecting electric pig-iron furnaces, in which I have been interested for a great many years, and had the opportunity to see eleven out of the twelve furnaces which are in operation. The first plant visited was at Trollhättan, where the original Jernkontoret furnace of 1912 is still in operation.<sup>1</sup> Mr. E. Nystrom is in charge of the plant. A second has been built alongside of it. Both are being run very steadily and uniformly on a medium-grade iron ore, making a pig iron which is going into commercial use, using only charcoal as a fuel.

This may be said about the use of the electric furnace as compared with the blast-furnace in Sweden: At the present time, charcoal is cheaper than coke, and therefore it is cheaper to run with charcoal; the electric pig-iron furnace thus has the advantage of working at its best, under conditions where the blast-furnace can hardly compete with it. Pig iron produced by those furnaces is costing, in Sweden, about \$5 per ton less than their own blast-furnace pig iron.

I hardly think that any more blast-furnaces will be built in Sweden. Possibly a few may be in certain localities, but wherever water power is available for producing electricity, certainly the electric pig-iron furnace can operate more cheaply in Sweden than the blast-furnace can.<sup>2</sup>

The next plant visited was at Domnarfvet. They have four furnaces,<sup>3</sup> three of which were in operation. The fourth was idle on account of shortage of water power, it being the dry season. These furnaces show very plainly the successive development of the electric furnace. The first electric pig-iron furnace in Sweden was erected in Domnarfvet; that first one has been torn down and a more modern one is being erected in its place.

\*Following a session on Iron and Steel at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers, at which he presided, Dr. Richards made these remarks regarding Electric Iron Smelting, as he found it.

<sup>1</sup>MET. & CHEM. ENG., vol. 9, 1911, pp. 368, 459, 505; vol. 10, 1912, p. 413.

<sup>2</sup>For a discussion of details of electric smelting of iron ore, see MET. & CHEM. ENG., vol. 12, 1914, pp. 82, 223, 444.

<sup>3</sup>MET. & CHEM. ENG., vol. 16, p. 509.

The four other furnaces show four successive steps in the electric pig-iron furnace development at that plant. The latest one is of 4500 kw., nearly 6000 hp. The whole plant is substantially erected, and gives one the impression of being around a modern blast-furnace plant. It is smaller, but the appliances are functioning so well and the uniformity of running is such as to give one the impression that here is a commercial running plant.

At Hagfors, 100 miles west of Domnarfvet, there are five electric pig-iron furnaces, and they are working very well. I spent half a day there with Mr. Bergquist, in charge, discussing all the points of the furnace plant. They have gradually changed first one thing and then another, widening out the neck of the furnace at the lower part, improving the holders, electrodes, etc. They have electrodes up to 30 in. diameter in use, and the replacement of the arch of the furnace when it becomes damaged is now well taken care of. There are other details of operation which were being mastered in about the same way that we are used to seeing around ordinary blast-furnaces.

It seems to me the experience which has been gained by the Swedish plants is sufficient to make them practicable in a great many parts of the world, and I expect to see in the near future a considerable extension of the use of these furnaces in such countries as Canada, Italy, Brazil, Mexico, Japan, or other places where high-grade iron ore is available and there is a good supply of charcoal and cheap electric power. Electric power in Sweden is now costing more than it did before the war, because the plants are requiring increased hydro-electric installations which cost much more to install now than formerly. The era of \$8 a year horsepower is past. It is now averaging more nearly \$10 to \$12 in the developments which are now under way.

#### ELECTRIC STEEL

As regards electric furnace steel, I visited the largest electric steel works in Norway. These works, at Stavanger, have been for some years making very fine qualities of electric steel, melting down steel scrap in an open-hearth furnace and then refining in an induction electric furnace. Before the war they found it cheaper to do the melting in the open-hearth furnace than to do it in an electric furnace, even though power was costing them only \$6 per hp.-yr. But with the increased price of coal during the war (it cost up to \$80 and \$90 a ton, but it is now down to \$20) they have calculated that they can melt cheaper in the electric furnace than in the open-hearth furnace using coal. Therefore, that same company has put in two furnaces, one of the Frick type, and the other of the Heroult type, so that henceforth its practice will be to melt cold charges in the electric furnace instead of using its former duplex open-hearth electric practice.

#### LABOR CONDITIONS

I found the labor conditions in Sweden better than in Norway, but in both countries it is much worse than here. Particularly in Norway, the labor element is extremely disquiet, especially among the younger unmarried men, between 20 and 25 years old. They go around with pipe in mouth, hat on one side, hands in pockets, and have the Bolshevik ideal of doing as little work as possible and getting impossibly high pay for it.

There also seems to be an almost entire lack of confidence and understanding between employers and em-

ployees. For instance, the employers may be trying to figure out whether they can keep the business running and make any profits, when the workmen come around with a demand for 50 per cent increase in pay and a 6-hr. day. The employers then throw their hands up and say that it isn't in it. Many of the plants operating in Norway cannot pay the demand of the laborers for wages and keep running, so that the workmen are killing their own chances for getting higher wages.

If it is said to these workmen that the industry cannot stand the high prices which they demand, they reply: "We don't believe it. They could give it to us if they wished to. It is merely greed that prevents the employers from making a profit; if they can't run it, let the government take it over."

That is the attitude of a large part of the labor element in Norway. It is certain that if private enterprise cannot operate and make a profit, then it is impossible for the government to do so.

#### REMEDY FOR LABOR UNREST

There seems to be a deadlock at the present time, which can only be solved in one of two ways; that is, either that the men get hungry and have to work, or that a re-establishment of confidence can be had between the employer and employee, by putting an employees' representative on the board of direction and working on the co-operative plan.

I believe that this will come. I talked with many men, some high up in governmental and industrial circles, and they seemed to think that it would be a good plan thus to have the workmen find out the actual condition of the business and the possibilities of wages, because, as one sees it now, there is absolutely no limit to the workmen's demands except the blue sky. If they demand so much and get it, they want more and more. The actual limit is necessarily imposed by the condition of the business itself. If the representative of the workmen upon the board advises the workmen that certain things are possible and others impossible, then it is hoped that the workmen may be reasonable enough not to demand what their own representative tells them is the impossible.

The near future, I think, will see this development. The cards will have to be placed on the table. The greed of some employers who want, if it is possible, to make 100 per cent off their capital in a year, and put it in their own pockets, will be blocked, and I think this will lead to a fairer distribution of the profits resulting from the co-operation of labor and capital. It seems to me that this offers the best prospect toward a re-establishment of confidence, and a return to intensive industrial operation.

#### Foreign Commerce of United States for 1918

In compliance with recent legislation requiring that the annual report on the foreign commerce and navigation of the United States hereafter cover the calendar instead of the fiscal year, the Bureau of Foreign and Domestic Commerce has published statistics of United States trade with foreign countries for the year ended Dec. 31, 1918. The previous report published covered the fiscal year ended June 30, 1918, so, in order to provide a continuous record, the half-year period from July 1 to Dec. 31, 1918, is shown separately. Copies of this publication may be procured from the Superintendent of Documents, Washington, D. C.



## Melting Point Methods at High Temperatures—II

A Description of the Determination of Melting Points of Metals, Alloys, Salts and Refractory Materials by the Use of Thermo-Electric, Resistance and Optical Pyrometers\*

By LEO I. DANA AND PAUL D. FOOTE

ON account of the low heat diffusivity and latent heat of fusion of salts and silicates, considerable difficulty is encountered because of the obliquity of the melting or freezing curves. Consequently it is necessary to use tall, narrow charges and slow rates of heating. Few salts can be heated in a reducing atmosphere, and hence graphite crucibles are prohibited. Porcelain and fire clay are attacked by most salts, so that metal crucibles must be employed. Of these platinum, platinum alloys, and nickel have the widest utility. The thermocouple protecting tube of porcelain must itself be protected by a thin metal sheath. In many cases salts do not attack platinum perceptibly, so that the thermocouple may be im-

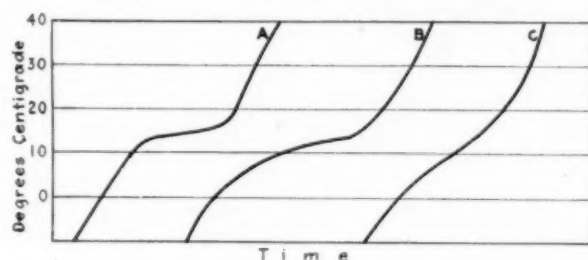


FIG. 12. SILICATE MELTING CURVES

mersed directly in the molten salt. When this is done, the crucible must be free from volatile metals such as iridium, especially for work at high temperatures; otherwise the couple will become contaminated. If no protecting tube is employed, very small crucibles may be used, from 1 to 2 cm. in diameter and 2 to 4 cm. high. If the salt is quite volatile and the vapors distill into the furnace, an additional protection tube for the furnace heater is necessary. The melting or freezing points of the nitrates, chlorides and sulphates of the alkali and alkali earth metals may be determined as above.

The melting points of silicates and other compounds of metallic oxides are usually comparatively high, and their great viscosity when liquid, their slow melting, slow crystallization, and undercooling introduce many difficulties in the melting point determination. Many crystalline silicates which have a definite melting point do not show a definite freezing point on account of the high viscosity of the liquid, thus preventing the formation of crystal nuclei. The liquid supercools and the viscosity may so increase that a glass is formed; thus borax may be melted but once, and on cooling a clear glass results which with reheating shows no marked heat transformation at the melting point. Other materials acting in this manner to a lesser degree are diopside,  $\text{MgSiO}_3$ ,  $\text{CaSiO}_3$ , melting at 1391 deg. C., and lithium metasilicate,  $\text{Li}_2\text{SiO}_3$ , melting at 1202 deg. C.

Consequently in silicate melting point determinations the melting curves are almost exclusively considered. In Fig. 12 A represents about as good a curve as is usually obtained with a silicate.

In another class of silicates the melting requires a large time interval, probably on account of the high viscosity of the liquid, so that the material will easily superheat as well as supercool. Both the melting and freezing curves may be so oblique that no halt in the curves is perceptible. In Fig. 12 C shows a heating curve for a slow melting silicate, which gives practically no information as to the true melting point. Silicates of this class may be differentiated by studying the melting curves obtained for different rates of heating. If the faint trace of a halt in the melting curve shifts with rate of heating, it is fairly conclusive evidence that this method is not applicable. A method which has been employed for such materials by the Geo-

physical Laboratory is to heat the substance for a considerable time at various constant temperatures and after quenching in mercury, investigate the crystalline properties under a petrographic microscope. The crystalline structure is destroyed by the melting. Materials of this type are albite,  $\text{NaAlSi}_3\text{O}_8$ , melting below 1200 deg. C., orthoclase,  $\text{KAlSi}_3\text{O}_8$ , and quartz,  $\text{SiO}_2$ , melting at 1710 deg. C.

The apparatus used by the Geophysical Laboratory for silicate work is shown in Fig. 13. The marquardt or sillimanite porcelain tube A is jointed to a platinum sleeve B, 5 x 1.2 cm., into which tightly fits the platinum crucible containing the charge. The platinum thermocouple, carefully centered, is inserted with no protection. Great care must be taken to avoid the presence of impurities such as chips of porcelain from the tube A, etc., as the lowering of the freezing point by impurities is proportional to the square of the absolute temperature and becomes very serious at high temperatures. In Fig. 12 B shows a heating curve of a silicate containing an impurity.

White has found that in general the electrical leakage through the molten salt is not of serious importance. However, this must be considered for precision work at high temperatures, as well as the leakage from the furnace heating current to the couple. The latter may be diminished by preventing any part of the heated couple or crucible from coming into contact with the furnace wall. Thermionic leakage to the couple may be minimized by electrostatic shielding.

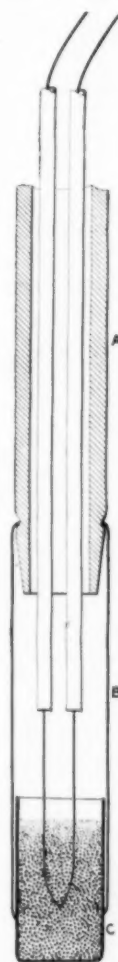


FIG. 13. Silicate Melting Point Apparatus

\*Part I was published in CHEM. & MET. ENG., Vol. 22, No. 1, pp. 23-28, Jan. 7, 1920.

Leakage may usually be detected by moving the couple, and by reversing or cutting off temporarily the heating current.

The rate of heating should be from 2 to 8 deg. C. per minute. On account of the tendency of the melting curves to obliquity and on account of the small heat transformations involved, it is necessary to maintain a careful furnace control so that irregularities in heating will not appear on the melting curve. Even then it is possible that more sensitive methods of thermal analysis may be desirable, such as the inverse rate or the differential methods described elsewhere.<sup>1</sup>

#### PLATINUM-WOUND FURNACE

Since an oxidizing atmosphere is necessary, the furnace employed for high melting point work with salts and silicates must be wound with platinum. Fig. 14 shows a furnace suitable for temperatures up to 1550 deg. C. The tube A, of Norton alundum R. A. 98, 33 cm. long, 3 cm. bore, and 3 mm. wall, is wound with platinum or platinum-rhodium ribbon B, 1 to 2 cm. wide and 0.01 or 0.02 cm. thick with the turns about 3 mm. apart. The ends of the foil are bound with a turn of

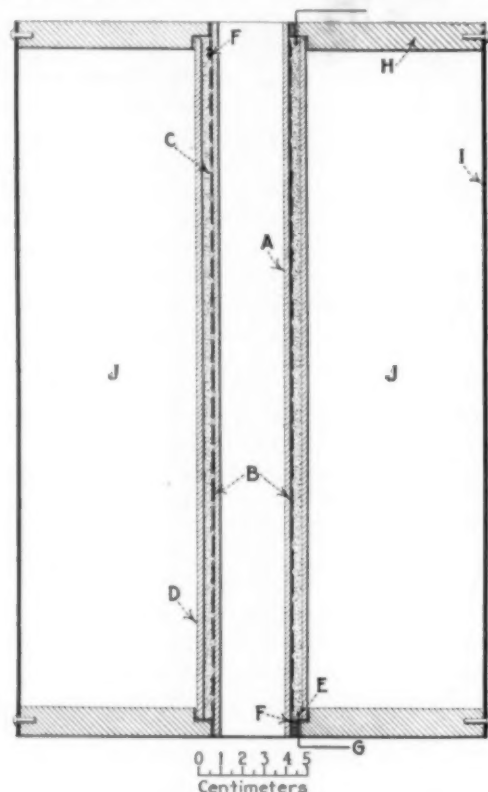


FIG. 14. PLATINUM-WOUND MELTING POINT FURNACE FOR SILICATES AND METALS

platinum wire F, to which are fused the heavy silver lead wires G. Around the tube A is a second tube D, and the space between the two tubes is packed with Norton R. R. alundum 120 mesh to prevent local heating of the ribbon. The space between the shell I and the tube D is filled with sintered magnesite.

**Table of Melting Points.** Table III gives the melting points of several salts and silicates determined at the Geophysical Laboratory.

**Technical Melting Point Determinations.** For ordi-

<sup>1</sup>For further details on silicates see publications of the Geophysical Laboratory in the *Am. J. Sci.*, and Jaeger, "Physico-chemical Measurements at High Temperatures," Walters, Groningen, Holland, 1913.

nary technical testing in which an accuracy of 5 to 10 deg. C. is sufficient the general procedure is the same as that discussed for precision work except that less care is required in experimental details. When large crucibles are used it is necessary to procure much larger crucibles, approximately in the same proportion illustrated by Table I.<sup>†</sup> It is not a wise practice to immerse a bare base metal couple directly in a molten salt or

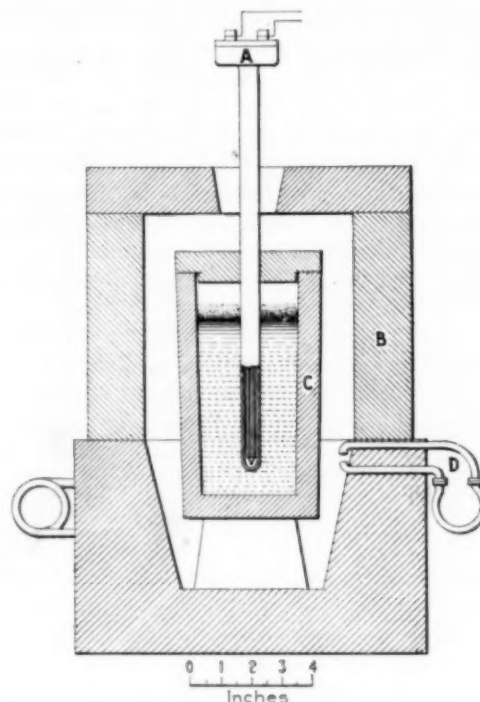


FIG. 15. GAS FURNACE FOR TECHNICAL MELTING POINTS

metal. The couple should be protected by a metal or ceramic tube, preferably of thin wall in order to reduce heat conduction. For metals, Dixon graphite crucibles, which are less susceptible to oxidation than the Acheson graphite, or pure fire clay (except for aluminum) are satisfactory, while for salts iron, calorized iron, nickel nickel-chromium alloys or Duriron are serviceable. For

TABLE III. MELTING POINTS OF SALTS, SILICATES AND OTHER COMPOUNDS

Substance	Formula	Melting Point Deg. C.
Sodium molybdate.....	Na <sub>2</sub> MoO <sub>4</sub>	687
Borax.....	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub>	741
Sodium chloride.....	NaCl	801
Sodium sulphate.....	Na <sub>2</sub> SO <sub>4</sub>	884
Sodium metasilicate.....	Na <sub>2</sub> SiO <sub>3</sub>	1088
Lithium metasilicate.....	Li <sub>2</sub> SiO <sub>3</sub>	1202
Lithium orthosilicate.....	Li <sub>4</sub> SiO <sub>4</sub>	1255
Eutectic between diopside.....	MgSiO <sub>3</sub> , CaSiO <sub>3</sub>	60 per cent } 1357
and calcium metasilicate.....	CaSiO <sub>3</sub>	40 per cent }
Penta-calcium tri-aluminate.....	5CaO, 3Al <sub>2</sub> O <sub>3</sub>	1382
Diopside.....	MgSiO <sub>3</sub> , CaSiO <sub>3</sub>	1391
Eutectic between calcium.....	CaSiO <sub>3</sub>	77 per cent } 1426
metasilicate and cristobalite.....	SiO <sub>2</sub>	23 per cent }
Calcium metasilicate.....	CaSiO <sub>3</sub>	1540
Anorthite.....	CaSiO <sub>3</sub> , Al <sub>2</sub> SiO <sub>5</sub>	1551
Magnesium metasilicate.....	MgSiO <sub>3</sub>	1554
Calcium aluminate.....	CaO, Al <sub>2</sub> O <sub>3</sub>	1592
Cristobalite.....	SiO <sub>2</sub>	1710

the checking of thermocouples, pots of commercial tin, lead, zinc, sodium chloride and copper of a fair degree of purity are sufficient. The melting points of these materials will rarely differ from those of the pure substances by 10 deg. C., and if close checks are required the melting points may be determined by means of an accurately calibrated couple. A gas furnace may be employed for heating, but the flame should not be allowed

<sup>†</sup>See CHEM. & MET. ENG., vol. 22, No. 1, p. 24.



to strike the crucible on one side only. If the burner is directed along a radius of the furnace instead of tangential to its surface, a baffle may be interposed before the crucible or the crucible may be mounted on a pedestal above the flame. Under these circumstances it is desirable to protect the crucible by an outer metal tube. An excellent form of gas furnace is the melter's furnace made by the American Gas Furnace Co. and illustrated by Fig. 15. For ordinary laboratory work size No. 3 is suitable. The furnace is provided with three burners *D*, only one of which appears in the drawing, mounted tangentially to the circumference in order to produce a spiralling flame. Excellent temperature uniformity is thus obtained.

**Wire Method.** The wire method of determining melting points of metals consists in inserting at the hot junction of the couple a small length of wire drawn from the material to be investigated. Usually a rare metal couple is employed. The couple is cut apart at the hot junction and the sample wire, preferably of about the same diameter as the wire of the couple and about 1 cm. or less in length, is fused (not soldered) in. The couple is then mounted in a narrow tube, which may be closed at the lower end, and inserted into a uniformly heated furnace as illustrated by Fig. 16. The temperature of the furnace is increased very slowly as the melting point is approached and the emf. of the couple is observed at the instant that the circuit is broken by the melting, evidence of which is shown by the galvanometer deflection of the potentiometer or of the simple indicator dropping to zero. The temperature corresponding to this emf. on the calibration curve of the couple is the desired melting point. The introduction of the short piece of metal produces no effect on the thermo-electric circuit, provided it is at a uniform temperature. The two metals most satisfactorily employed with this method are gold and palladium, although many other metals could be used with the proper atmosphere. The experimental manipulation for palladium is a little difficult. A platinum-wound furnace similar to Fig. 14 must be used, and the two insulating tubes of the couple must not come into contact with each other or with the furnace walls; otherwise electrical leakage occurs. A leak between the wires of the couple produces a peculiar effect at the instant of melting of the palladium. Instead of the galvanometer showing zero deflection it will indicate the very large voltaic emf. developed when the porcelain acts as an electrolyte, since the metallic shunt of low resistance across this emf. is broken when the palladium melts. With proper care, results by this method are reproducible to 1 deg. C. It is frequently convenient to sight a microscope of low power on the loop of wire and observe the melting. If the rate of heating is slow, sufficient time elapses from the incipient melting to secure several reliable potentiometric readings before the circuit is broken.

The wire method is occasionally employed for copper heated in air. The temperature so obtained, however, is not reliable. It may be any value from 1063 to 1083 deg. C., depending upon the rate of heating and hence upon the amount of oxide formed.

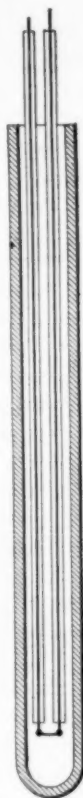


FIG. 16.  
APPARATUS  
FOR WIRE  
METHOD

## II. Use of Resistance Thermometers

The standard temperature scale as used and distributed by the Bureau of Standards is defined in the interval —40 to 450 deg. C. by means of platinum resistance thermometers calibrated in ice, and steam and sulphur vapor (444.6 deg. C.). Platinum of a high degree of purity is readily obtainable, and its purity is assured if the mean temperature coefficient of resistance of the thermometer between 0 and 100 deg. C. is not less than 0.00388 and if the constant  $\beta$  of the Callendar equation used for expressing the relation between temperature and resistance is not greater than 1.52. The temperature scale from 450 to 1100 deg. C. is defined by the melting points of pure antimony, silver, gold and copper and interpolation between these points is based on the temperature scale defined by the rare metal couple (Pt-90 per cent Pt, 10 per cent Rh) calibrated at two of these fixed points, antimony and copper, and a third point, zinc, fixed by the resistance thermometer.

### ADVANTAGES OF RESISTANCE THERMOMETERS

It has been found that the scale defined by the resistance thermometer calibrated as above agrees with the thermocouple scale as closely as this may be reproduced, even up to 800 deg. C. Above this range the behavior of a resistance thermometer is likely to be erratic. The calibration is subject to changes on account of volatilization of the platinum and strains introduced by the warping of the mica frame upon which the wire is wound. Reliable precise measurements can be obtained only by inter-comparison of several thermometers. Below 800 deg. C., however, the temperature scale defined by the resistance thermometer is probably more closely reproduced by different resistance thermometers than is the thermocouple scale reproduced by different thermocouples. Hence when very high precision is required, 0.1 deg. C. or better, the resistance thermometer offers some advantages in the range 450 to 800 deg. C. Below 450 deg. C. the resistance thermometer is the most accurate means of temperature measurements, since its temperature scale is accepted as standard. In melting point work of the highest precision from 450 to 800 deg. C. there is some question as to whether the error resulting in a temperature gradient over the entire bulb of a resistance thermometer introduces as large an error as may arise with a thermocouple, which requires a much smaller region of temperature uniformity, for example the errors due to inhomogeneity of the wires of the couple.

The general technique to be observed in melting point determinations with the resistance thermometer is the same as that required in thermocouple work of the highest precision. The large size of crucible described in Table I is necessary since the bulb of the thermometer is from 5 to 8 cm. long. The most extensive paper on the application of resistance thermometers to melting point determinations is by Waidner and Burgess.<sup>8</sup> This paper contains a complete bibliography up to 1909. Later developments have been made only in the methods of measurement, such as bridges, etc., and are described by Waidner, Dickinson, Mueller and Harper and by Mueller.<sup>9</sup>

<sup>8</sup>Waidner and Burgess, Bu. of Standards, Scientific Paper No. 124.

<sup>9</sup>Waidner, Dickinson, Mueller and Harper, "A Wheatstone Bridge for Resistance Thermometry, Bu. of Standards, Scientific Paper No. 241. Mueller, "Wheatstone Bridges and Some Necessary Apparatus for Resistance Thermometry," Bu. of Standards, Scientific Paper No. 288.

### III. Use of Optical Pyrometers

#### METALS AND ALLOYS

Above 1400 deg. C. the difficulties involved in the use of thermocouples for melting point determinations are very great. Refractory tubes are attacked by the metals and are permeable to gases which contaminate the couple. The calibration of the couple changes, inhomogeneity develops and troubles arise from electrical leakage. For these reasons the use of optical pyrometers is desirable, and, above 1550 deg. C., necessary. The disappearing filament type of optical pyrometer is most satisfactory, since it is capable of high precision and requires a very small source upon which to sight. Special care must be given in the use of optical pyrometers to insure that black body conditions are closely approximated.

For metals and alloys melting below 1750 deg. C. the experimental device shown in Fig. 17 is suitable. The outer tube is made of sillimanite porcelain, melting at 1810 deg. C., and constitutes the unit to be inserted into a furnace. The crucible inside this tube is about 18 mm. in diameter and 20 mm. high, and is provided with a cover having two holes, 2 to 3 mm. in diameter, in the positions illustrated. The pyrometer is focused on the outer hole, and the central hole is for observing the progress of a freezing or melting. If the metal in the crucible is molten, the central hole appears quite dark against a brighter background because the level metal surface reflects the image of the upper and cold part of the furnace. The surface under the side hole, however, is convex on account of the surface tension of the metal, and the V-shaped depression formed between the metal and the side wall affords a satisfactory black body upon which to sight the pyrometer. The outer tube should be uniformly heated for a distance at least twice its diameter, and the short crucible should be filled about half full with metal. Tall crucibles are not desirable, as they are less likely to be uniformly heated and any non-uniformity disturbs the black-body conditions. Although it is realized that such a system is not

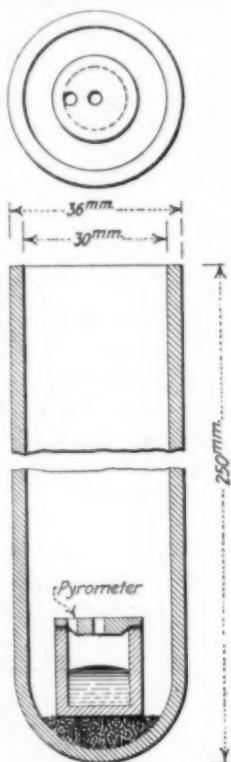


FIG. 17. APPARATUS FOR MELTING POINTS OF METALS AND ALLOYS WITH OPTICAL PYROMETER

Metal	Melting Point	Crucible Material	Atmosphere
Silicon.....	1420	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Vacuum, N <sub>2</sub> , H <sub>2</sub>
Nickel.....	1452	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Vacuum, N <sub>2</sub>
Cobalt.....	1480	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Vacuum, N <sub>2</sub>
Iron.....	1530	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Vacuum, N <sub>2</sub>
Palladium.....	1550	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Air
Chromium.....	1615	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Vacuum, N <sub>2</sub>
Platinum.....	1755	MgO, Al <sub>2</sub> O <sub>3</sub> , or mixtures	Air

ideal for producing black-body radiation, especially when the temperature is continually changing, as is necessary in melting point determinations, still it may be concluded on the basis of many careful observations that the error in general does not amount to more than 2 or 3 deg. C. For more precise work it is possible to

fix to the cover of the crucible a re-entrant tube immersed directly in the metal, and into which the pyrometer is sighted. This method is frequently employed for the standardization of an optical pyrometer by direct melting point determinations.<sup>19</sup>

**Table of Melting Points.** Table IV gives the melting points of several pure metals which with their alloys may be investigated by the above method.

**Crucibles.** Crucibles containing either graphite or silica must never be used for precision work with these metals and their alloys. Silica-free crucibles are not sold by the porcelain manufacturers, but can be made in the laboratory without much difficulty from magnesia, alumina, or mixtures of the two. Pure magnesia aluminate does not begin to melt below 1925 deg. C., and hence is sufficiently refractory for the above metals. Pure fused alumina and pure fused magnesia made by the Norton Co. are ground to 150 to 200 mesh and mixed in the approximate proportion 75 per cent alumina and 25 per cent magnesia (the exact proportion is immaterial). The powder is slightly moistened and compressed in a briquetting mold similar to that illustrated by Fig. 18 into a cylinder having the outside diameter of the crucible. This cylinder is fired in a graphite crucible at a temperature of 1700 deg. C. for a few moments. The Arsem furnace described later, or any carbon resistor furnace having a clean atmosphere and capable of maintaining this temperature, is satisfactory.

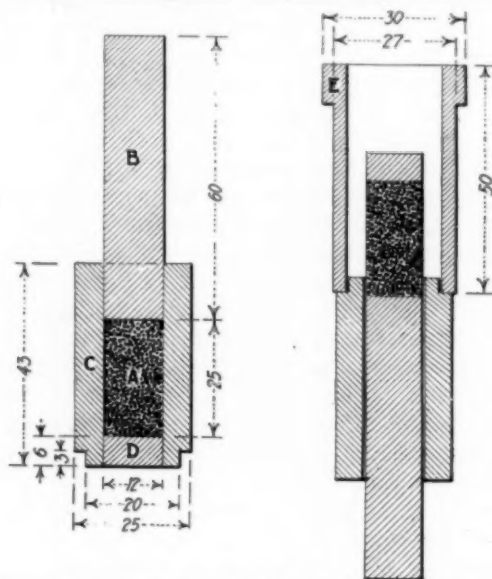


FIG. 18. BRIQUETTING MOLD FOR REFRACTORY MATERIALS

The cylinder sinters to a hardness sufficiently strong to be handled, and with care it is possible to drill out a hole large enough for the metal, with an ordinary twist drill. The crucible is then refired at a temperature between 1800 and 1900 deg. C. A cover is readily made.

For ordinary testing with metals other than palladium and platinum, the sillimanite crucible ("impervite" or "usalite") may be employed. These are of course attacked and must be discarded after each determination, but experiments indicate that the impurity introduced in the metal by a single heating affects the melting point less than 10 deg. C. Such crucibles are useful for ordinary work with steels and nickel-chromium alloys.

**Furnaces.** None of the metals or alloys of high melting point, except the rare metals, can be melted in air

<sup>19</sup>Kanolt, Bu. of Standards, Technical Paper No. 10. Foote, MET. & CHEM. ENG., vol. 11, p. 97; 1913.



without serious oxidation. The use of a vacuum furnace, the residual gases being CO and N<sub>2</sub>, is satisfactory except for palladium and platinum. Fig. 19 illustrates such a furnace designed by Arsem.<sup>11</sup> It is readily and accurately controllable and a clear atmosphere is assured. The graphite spiral C is mounted in water-cooled copper electrodes. F is a radiation shield of graphite filled with magnesia. The pyrometer is sighted through the glass window D into the sillimanite tube B (see also Fig. 17), which is suspended from the top of the furnace. In the place of A the crucible shown in Fig. 17 is mounted on a bed of alundum. The porcelain tube is fairly impermeable to the hot gases and carbon vapor. With the first heating in a vacuum furnace the liquid metal usually sputters on account of evolution of gases, and may throw off the cover of the crucible, but after the first melting satisfactory readings can be taken. Suitable rates of heating or cooling near the melting point are from 10 to 20 deg. C. per minute. In this range, temperature measurements should be made very frequently, every 10 seconds if possible. Fig. 20 illustrates typical freezing curves for pure iron and chrome steel by this method.

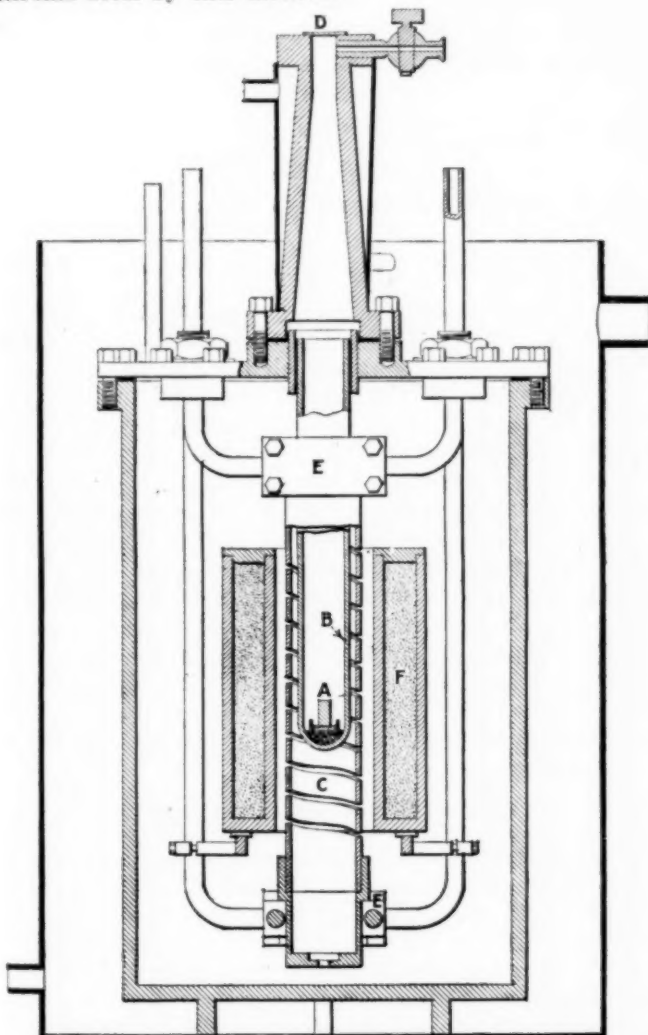


FIG. 19. ARSEM GRAPHITE RESISTANCE VACUUM FURNACE

For temperatures below 1550 deg. C. the sillimanite tube of Fig. 17 may be heated in a platinum-wound furnace if desired. The proper atmosphere for the metal can be obtained by fitting the sillimanite tube with a

<sup>11</sup>Arsem, *J. Am. Chem. Soc.*, vol. 28, p. 921; 1906. Kanolt, Bu. of Standards, Technical Paper No. 10, Scientific Paper No. 212.

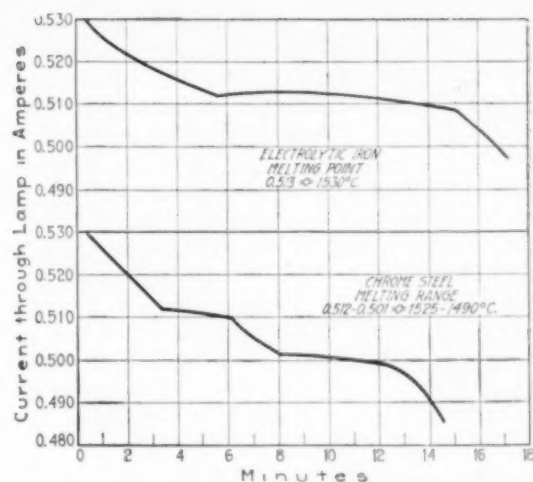


FIG. 20. FREEZING CURVES OF ELECTROLYTIC IRON AND CHROME STEEL

metal top containing a window and two side tubes through which N<sub>2</sub> is drawn. Another method is to insert a long porcelain tube through the furnace, in the center of which is mounted the crucible. Gas is led in at the top of this tube and out at the bottom.

Crucible melts of palladium and platinum are seldom made. Both of these metals must be melted in an oxidizing atmosphere, since in a reducing atmosphere the slightest trace of silica, which is present in nearly every type of furnace, is disastrous. Palladium may be heated in a lime, alumina, magnesia, or magnesia aluminate crucible in a platinum-wound furnace. Platinum could be melted in a furnace wound with a platinum-rhodium alloy, but the method has never been attempted. In several cases a furnace consisting of an iridium tube in which the tube serves as the resistor element has been used. The method is open to serious objections, however, on account of the rapid volatilization of iridium even when the material is coated with a protective paint such as a refractory earth mixture.<sup>12</sup>

**Other Methods.** For metals melting much above the range of platinum a modification of the wire method may be used. The material in the form of wire or ribbon is mounted as a filament of an electric lamp and is gradually heated electrically until it melts. The apparent or brightness temperature is measured by an optical pyrometer at the instant of melting. In order to correct the observed temperature to true temperature the value of the emissivity of the material must be known. This involves a separate and difficult experiment. In some cases the material in sheet form is folded into a wedge and electrically heated, and the pyrometer is sighted into the opening of the wedge, the radiation from which is approximately black. Various other methods are employed, such as sighting on a bead of the molten metal in an electric arc, extrapolation of the temperature-current curve for a lamp filament, etc.<sup>13</sup>

**Micropyrometer.** In order to determine the melting points of microscopic samples of materials Joly devised the maldometer. This consists of an electrically heated platinum strip the linear expansion of which is a measure of its temperature. The relation between elonga-

<sup>12</sup>Waldner and Burgess, Bu. of Standards, Scientific Paper No. 55.

<sup>13</sup>Waldner and Burgess, Bu. of Standards, Scientific Papers Nos. 40, 55. *J. d. Phys.*, vol. 6, p. 830, 1907. Forsythe, *Astrophys. J.*, vol. 12, p. 364; 1911. Mendenhall and Ingersoll, *Phys. R.*, vol. 25, p. 1; 1907. Pirani and Meyer, *Verh. d. Phys. Ges.*, vol. 14, p. 426; 1912. Wartenberg, *Verh. d. Phys. Ges.*, vol. 12, p. 120; 1909. Langmuir, *Phys. R.*, vol. 6, p. 152; 1915. Worthing, *Phys. R.*, vol. 10, p. 377; 1917.

tion and temperature is determined by placing samples of pure materials on the strip and observing the melting point through a microscope while the elongation is measured by a vernier screw adjustment. A more satisfactory method is by use of the Burgess<sup>18</sup> micropyrometer, which operates on the same principle as the disappearing filament pyrometer except that the lamp is mounted in a microscope instead of a telescope. (See Fig. 21.) This is sighted on a platinum strip, and on the strip in the field of view is placed a sample of the material to be melted, usually from 0.1 to 0.001 mg. in weight. The strip is enclosed in a water-cooled container having a clear glass window, and a reducing or neutral atmosphere is maintained. The temperature of the platinum strip is measured at the instant of melting, which is indicated with unmistakable evidence, since the material either gathers into a ball or spreads out on the strip. The pyrometer is calibrated by employing metals of known melting points. A natural question which arises is whether the sample actually takes up the temperature of the strip. If the sample were heated by radiation alone, since it receives radiation from a solid angle  $2\pi$  and radiates through a solid angle  $4\pi$ , it can be shown on the basis of the Stefan-Boltzmann law that the absolute temperature of the

convection compensating for the deficiency in the direct radiation. The method must be used with caution, however, when applied to other materials than metals, especially in a vacuum. It has been found that errors of 50 deg. or more resulted when gold was heated on a graphite strip in vacua.

#### REFRACTORY MATERIALS

**Refractory Oxides.** Refractory oxides are the basic constituents of minerals and of ceramic refractory materials. Their melting points are very high, and it is necessary to adopt special precautions to avoid contamination and to eliminate the smoke produced by the vaporization of the oxide. The Arsem furnace shown in Fig. 19 was used by Kanolt<sup>19</sup> for determining the melting points of magnesia, lime, alumina and chromium oxide. In each case heating curves by the temperature-time method were obtained with an optical pyrometer, and the results were confirmed by examination of the materials heated above and below the observed melting points. The rate of heating was about 100 deg. C. per minute near the melting point.

**Table of Melting Points.** Table V is a summary of Kanolt's work.

TABLE V.

Oxide	M.P. Deg. C.	Crucible Material	Atmosphere
MgO	2800	Graphite	Stream of CO and N <sub>2</sub> at atmospheric pressure.
CaO	2570	Tungsten, CaO	Stream of H <sub>2</sub> at atmospheric pressure.
Al <sub>2</sub> O <sub>3</sub>	2050	Tungsten, graphite	CO and N <sub>2</sub> vacuum; stream of CO and N <sub>2</sub> at atmospheric pressure.
Cr <sub>2</sub> O <sub>3</sub>	1990	Tungsten, graphite	CO and N <sub>2</sub> vacuum.

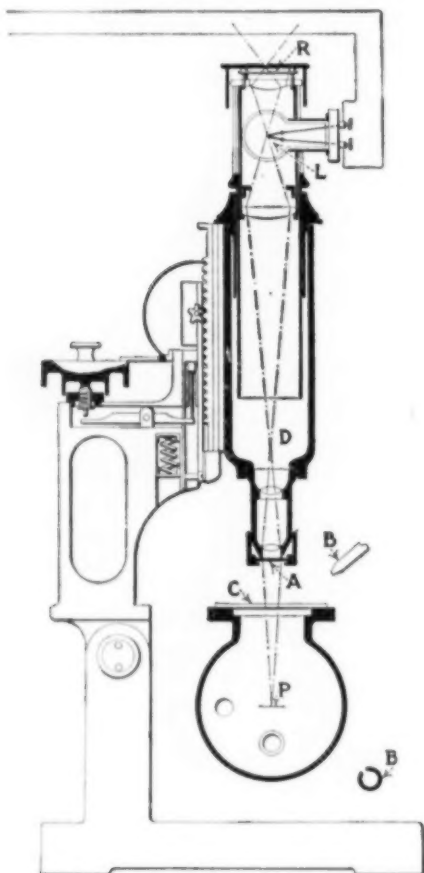


FIG. 21. MICROPYROMETER

sample would be roughly only 0.8 that of the strip. On the other hand, the microscopic sample acts as a shunt on the platinum strip and more heat is developed at this point, tending to increase the temperature. Thermal conduction along the strip reduces this effect. The fact that samples of different sizes appear to give the same value for the melting point indicates that these effects are very small and that the sample actually assumes the temperature of the strip, the heat conduction and gas

Magnesia was melted in a special form of graphite crucible, Fig. 22, which was mounted in the Arsem furnace. The pyrometer was sighted through the tube B on the bottom of the tube A immersed in the magnesia. CO and N<sub>2</sub> at atmospheric pressure were passed through BCD, thus clearing the field of view from smoke. Lime was melted in a similar container except that the parts in contact with the lime were made of tungsten. Fig. 23 shows another method employed for lime. The tube O compressed from pure lime was suspended in the furnace and a stream of hydrogen was passed in at P and out at Q to avoid the presence of smoke. Alumina was melted in vacuo in the same form of crucible used for magnesia and also in a graphite crucible shown by Fig. 24. This latter method with crucibles of both graphite and tungsten was employed for chromium oxide.

#### FIREBRICKS AND CERAMIC MATERIALS<sup>20</sup>

Refractory materials such as firebricks, fire clays and minerals are composed of compounds of the refractory metallic oxides, solid solutions of the oxides, pure oxides, and mixtures of these classes, together with a variety of chemical compounds. The oxides silica and alumina occur most commonly in refractory materials, and frequently in combination with these are the oxides of the alkali earth, the alkali, the iron group and the rare earth metals.

**Meaning of the Melting Point.** In the case of refractory materials which are either amorphous or heterogeneous mixtures of oxides and other substances there is no definite melting point. The change from the solid

<sup>18</sup>Kanolt, *loc. cit.*

<sup>19</sup>For a more detailed discussion, see L. I. Dana, *Bull. A. I. M. E.*, September, 1919.

<sup>20</sup>Bu. of Standards, Scientific Papers Nos. 198, 205, 242.



state to one in which the material will flow is gradual over both a temperature and time interval. In addition, physical and chemical reactions which are not equilibrium reactions often take place during melting. These phenomena practically prohibit the use of melting curves, and for ordinary technical purposes the criterion of marked flow, although indefinite from the pure scientific standpoint, is adopted. Accordingly, the practical definition of the melting point of a refractory material is that temperature at which under specified conditions a marked and distinct flow of the material begins. In terms of the deformation of a cone or cylinder the melting point is midway between the temperature at which the deformation begins and the temperature at which the material fuses into a lump or ball, or is completely bent over. The softening or fusing point of a refractory should be defined in the same manner, making the three terms synonymous. If the refractory is a pure crystalline compound it possesses a true melting point, but often, as for example with quartz and albite, the change of state takes place so slowly at the melting point that the substance may be superheated. Thus with quartz the viscosity is so high that a marked flow is not perceptible until the material is superheated by 40 or 50 deg. C.<sup>17</sup> For technical testing the criterion of marked flow is usually taken to define the so-called melting point even for pure crystalline compounds, and thus on the basis of such a definition the melting point of quartz is about 1750 deg. C.

*Conditions Affecting Observed Values of the Melting Point.* The results obtained on the basis of the above definition of melting point are influenced by a number of experimental factors as follows:

- (a) Chemical composition.
- (b) Size of the particles, and size, shape and orientation of the sample.
- (c) Time and rate of heating.
- (d) Pressure and chemical nature of atmosphere.

The relations between these factors are so complex that in most cases it is not possible to predict the magnitude or sign of the change in melting due to a variation in one or more of the above conditions. It must be noted that the melting point in actual use of the refractory material may differ considerably from that observed in the laboratory on account of the fact that the conditions of test in the laboratory are not reproduced. Thus contamination of the refractory by molten metals, slags, flue dust, etc., may alter the melting point because of the chemical reaction; also the time and rate of heating may be different. Under load the softening or melting point of a refractory is lowered on account of plastic flow. For this and other reasons the value of the melting point determined in the laboratory is not the only factor, as far as failure is concerned, to be considered in the choice of a refractory for an industrial installation.

#### PROCEDURE TO DETERMINE MELTING POINT

*Sampling, Grinding and Molding.* Firebrick and other refractories of non-uniform texture and composition or with particles larger than 30 mesh should be carefully sampled. It is accordingly necessary to grind the material and mold the powder into the form of a cylinder or cone. If the refractory is of fine and uni-

form texture, however, a piece may be chipped off and shaped to the proper form. Fine refractory powder may be briquetted directly. Since the size of the particles may affect the melting point, the degree of fineness should be specified, at least approximately. For a large variety of substances grinding to pass an 80-mesh screen has proved satisfactory. The material is then slightly moistened and compressed into a cylinder about 2.5 cm. high and 1.2 cm. in diameter by means of the brass or polished steel mold shown in Fig. 18. In this



Fig. 22



Fig. 23

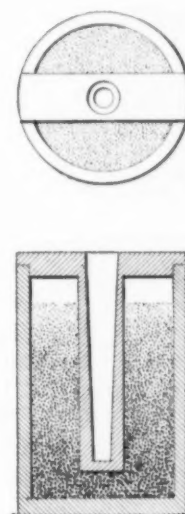


Fig. 24

FIGS. 22 TO 24

Left—Arrangement for melting magnesite. Center—Arrangement for melting lime. Right—Crucible for melting alumina and chromium oxide.

figure *C* is a cylinder, *B* the piston, *D* a plug and *A* the powder. In order to remove the compressed cylinder the mold is inverted, the cylinder *E* is placed on top and the sample is slowly pushed out.

*Time and Rate of Heating.* The rate of heating from room temperature to about 1000 deg. C. for substances melting above 1500 deg. C. may be very rapid. A satisfactory total time of heating is from thirty minutes to two hours with a rate of from 5 to 10 deg. C. per minute from about 50 deg. below the melting point and during melting. Since the observed melting point depends to some extent upon the rate of heating, it is necessary to specify the temperature-time curve in order that results be reproducible. The following table illustrates the manner in which this may be done with sufficient exactness:

Temperature Interval	Time in Minutes
Room temperature to 1000 deg. C. ....	20
1000 to 1650 deg. ....	25
1650 to 1700 deg. M.P. ....	5

*Type of Furnace and Conditions Existing Therein.* A furnace for melting refractories should be capable of easily maintaining a temperature of 1800 deg. C., and means must be provided for close temperature regulation. The atmosphere within the furnace must not react appreciably with the specimen; otherwise the material must be protected. Graphite or carbon tube and spiral resistance furnaces operated in air oxidize rapidly, but may be somewhat protected by passing a neutral or reducing gas through them. The gas may

<sup>17</sup>Quartz begins to flow at 1750 deg. C. (Kanolt, Bu. of Standards, Technical Paper No. 10), while its true melting point is 1710 deg. C. (Ferguson and Merwin, *Am. J. Sci.*, vol. 46, p. 1; 1918).

also serve the purpose of carrying away smoke so that accurate optical temperature measurements may be made. Crushed carbon, graphite, kryptol, or carbon plate resistor furnaces do not permit of very precise regulation. Some forms of furnaces are so constructed that it is difficult to use an optical pyrometer. The vacuum furnace of the Arsem type, although requiring greater accessory apparatus, is more desirable on account of its freedom from smoke and because good control is possible at extreme temperatures, even at 2500 deg. C. Furthermore, the atmosphere can be made much less reducing than that in an ordinary graphite furnace. Many refractories are seriously attacked in a carbon and carbon monoxide reducing atmosphere and it is usually not possible to judge by simple inspection of the melted sample whether or not the reduction is appreciable. In many cases the surface of the specimen is attacked and a shell of higher melting point is formed, so that while the inner uncontaminated material may have been melted there is no outward evidence of this fact. In general the sample should be protected from the reducing atmosphere by a refractory tube of low porosity. In the Arsem furnace the sample A, Fig. 19, is protected by the sillimanite tube B. For temperatures beyond 1800 deg. C. no suitable protection tubes have been made. In certain special cases it may be desirable, if possible, to determine the melting point of a refractory under the atmospheric conditions to which it is subjected in actual use. Indirectly the pressure of the atmosphere may affect the melting point. For example, in a vacuum the more volatile and fusible substances, such as alkalis, may distill and thus cause a rise of melting point.

There appear to be some possibilities in the development of gas furnaces for high melting point determinations. With a suitable construction and air pressure of 10 lb. and more, temperatures of 1650 deg. C. may be maintained with illuminating gas and 1800 deg. C. with natural gas. By recuperating the waste heat or by preheating the gases the above temperature limits may be increased. It should be pointed out that for reliable melting point work it is necessary to maintain a high temperature not on a restricted small surface but throughout a considerable volume.

**Temperature Measurements.** Pyrometric cones have been employed as a rough measurement of the melting temperature of refractories. The refractory is thus said to have a softening point corresponding to a certain cone number. Seger and similar cones serve a useful purpose under slow rates of heating in measuring heat effects during the firing of ceramic products, but in the laboratory, when the rates of heating are comparatively rapid and may vary considerably, the determination of the cone softening point is not of much significance. For it has been repeatedly shown by numerous investigators<sup>19</sup> that the softening point of Seger cones depends upon the nature of the atmosphere and especially upon the time and rate of heating. Usually the more rapid the rate of heating the higher the softening temperature, variations of 50 deg. C. being easily obtained. In order that the indications by a Seger cone possess reliability it is necessary to specify the atmosphere and the time-temperature curve in the manner illustrated above for refractories. Thus in the ordinary use of Seger cones a variable factor is introduced in the temperature scale defined by the cone numbers which may

have no relation to the properties and characteristics of the refractory being tested. Hence it is essential to use a strictly fixed and reproducible temperature scale. This is best accomplished by means of the disappearing filament type of optical pyrometer.

A very slight departure from black-body conditions enables one to discuss the specimen and to watch the progress of melting. It is important to keep the eye fixed on the sample in order that the melting may be observed with certainty. Sintering and vitrification take place on heating, sometimes producing shrinkage and bending; this must not be confused with the change in shape on melting. As in the case of metals, the pyrometer should be focused on a surface of the sample oblique to the line of sight, but it must be assured this surface is not reflecting light from a hotter section of the furnace, thus causing too high a reading. After the determination the sample is removed from the furnace, broken apart and inspected. The inside surface should appear homogeneous and amorphous or glassy. When the sample has been melted in a vacuum furnace a cellular structure is usually apparent, due to gases evolved during melting.

**Softening Temperature of Coal Ash.** The clinkering of coal ash is closely related to its softening temperature. Consequently the determination of this tempera-

TABLE VI. MELTING POINTS OF COMMON REFRACTORY MATERIALS

Material	Temperature, Deg. C.
Fire Bricks:	
Fire clay.....	1500-1750
Silica.....	1700-1750
Magnesia.....	2150
Bauxite.....	1600-1800
Chromite.....	2050
Clays and Sands:	
Kaolin, $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ .....	1740
Fire clays.....	1400-1740
Bauxite clay.....	1800
Bauxite, $\text{Al}_2\text{O}_3(\text{OH})_3$ .....	1820
Chromite, $\text{FeO} \cdot \text{Cr}_2\text{O}_3$ .....	2180
Silica.....	1750
Silica sands.....	1700-1750
Miscellaneous:	
Coal ash.....	1100-1500
Alundum cements.....	1750-2000

ture is of considerable practical importance. The Bureau of Mines has made a complete investigation of the factors and conditions affecting the fusibility of coal ash.<sup>20</sup>

The following procedure is recommended. After thoroughly roasting the coal, the ash is ground to 200 mesh and roasted again in a current of oxygen. Using a 10 per cent dextrine solution as a binder, small triangular pyramids, 20 mm. high and 6 mm. wide at the base, are made from the powdered ash. These are placed vertically in a muffle or crucible.

A yellow flame burning at least 15 cm. above the cover is maintained, and the rate of heating before and during softening should be from 5 to 10 deg. C. per minute. The softening temperature is the point at which the cone fuses down to a lump or ball.

**Table of Melting Points of Refractory Materials.** The melting points in Table VI were determined at the Bureau of Standards principally by Kanolt, under conditions approximating those described in the section on refractory material. With the exception of pure kaolin and silica, different samples of the same general type of material may have melting points considerably different from the values tabulated.

<sup>19</sup>Sosman, *Trans., Am. Cer. Soc.*, vol. 15, p. 482; 1913.

<sup>20</sup>Fieldner, Hall and Field, Bureau of Mines Bulletin No. 129.



## The Eventual Retort Plant for the Distillation of Oil Shales

BY LOUIS SIMPSON

IN THE Aug. 15, 1919, issue of this journal, in an article treating upon Oil Shales and upon the Scotch Dual Purpose retort, the principles that underlie successful retorting have been discussed at length.<sup>1</sup> In the Jan. 7, 1920, issue the question as to where it is commercially desirable to recover the nitrogen content of these shales has been answered.<sup>2</sup> It seems probable that many of those interested in the exploitation of oil-yielding shales have by this time arrived at the conclusion that the Scotch dual purpose retort is not the most economical retort possible to construct and operate for the eduction of the oil gases. Yet owing to certain qualities of shale containing by-products which it is desirable to recover because of the large quantity present or from local conditions that make their recovery profitable, it is necessary to consider the construction of a plant specially adapted for the recovery of one or more of such by-products as may be found in the spent shale. For those with such a problem this article is written.

It is probably admitted by those who seek the truth and who possess an unbiased mind that the most efficient retort for generating oil gases will be one specially designed for that purpose, without having regard to the recovery of nitrogen or of any of the possible by-products. The present problem to be considered therefore is how best to recover such by-products from the spent shale, that is, from the shale as it leaves the retort after the oil gases have been driven off.

### SUGGESTION THAT TWO MACHINES BE USED

There seems to be no special reason other than that it has been a matter of convenience that the recovery of the oil gases and the recovery of the nitrogen should have been attempted on one and the same machine, even if essayed in different sections of the machine. This convenience seems to have existed in the method adopted for heating the Scotch dual purpose retort, but herein is found the great weakness of the retort.

The Scotch designers of the retort had a glimmering of the situation. They knew that the temperatures created by the combustion of the fuel used, whether solid or gaseous, were too high for the best evolution of oil gas, and so arranged to use the higher range of temperatures available for the recovery of the nitrogen, using the lower range for the eduction of the oil gases. This seemed to be a satisfactory solution of the difficulty, but in truth they placed themselves between the horns of a dilemma. If that section of the retort in which the nitrogen gases are driven off as ammonia gas was subjected to the comparatively high temperatures required, that section of the retort was soon put out of commission, and further provided a temperature far too high for satisfactory eduction of the oil gases in the other section of the retort. With such comparative high temperatures, the hydrocarbons were cracked, with the result that permanent gas was formed and the yield of oil was reduced. If, on the other hand, the temperature in the nitrogen recovery section be reduced to the safety point, so that the retort may not be

burned out too quickly, then the recovery of nitrogen is very much less than the maximum possible.

Another point will be evident to the careful thinkers, viz., that the shale when it is passed to that section of the retort in which the recovery of the contained nitrogen is attempted is not in the best physical condition to give a maximum recovery, nor is it so placed, within the section, that each and every particle of the shale is submitted to the like high temperature. That disabilities exist is evidenced from the recoveries obtained, which do not exceed and usually fall under 60 per cent of the content.

Under these conditions it is surely evident that it is not possible to secure from the shale an economical extraction of the by-products, after the oil gases had been driven off, in the Scotch dual retort and that such extraction should take place in a machine especially designed for the purpose and constructed so as to withstand the necessary high temperatures.

### REQUIREMENTS OF MACHINE TO EXTRACT BY-PRODUCTS

The requirements of such a machine would be:

1. Capability of withstanding the comparative high temperatures necessary, without breaking down.
2. Every particle of shale under treatment must be subjected to the same heat treatment.
3. The spent shale, when under treatment, should be in a very finely disintegrated condition.

To obtain economically the high temperatures necessary, to provide that every particle of the shale shall receive the like heat treatment, the method of heating the spent shale has to be radically different from that used in the Scotch retort, and seeing that, at this stage, the shale has been freed from its hydrocarbon contents, there has ceased to be any reason why the shale should not be subjected to heat, *directly applied*, instead of as in the Scotch retort, *indirectly applied*.

Fortunately it is not necessary to invent any new machinery to meet the requirements of the case. The horizontal revolving kiln, so long and successfully used in the manufacture of portland cement to burn the "mix" into cement clinker, which is a perfected machine, seems to be peculiarly adapted for the work to be done.

In the manufacture of portland cement the "mix" (generally a mixture of clay and lime), finely ground, is subjected to temperatures of 1550 deg. C. (2820 deg. F.) and over. In the Scotch dual retort, the shale in the nitrogen recovery section is supposed to be exposed to a temperature somewhat around 1600 deg. F., but as there must be a great variation in the temperatures next to the walls of the retort and in those found in the center of the retort, it is difficult to ascertain just what temperatures are used. It is, however, now known that to obtain the recovery of the maximum yield of nitrogen as ammonia gas, every particle of the spent shale should be exposed to a temperature of 1125 deg. C., or 2060 deg. F. It is also known that a decrease of comparatively few degrees of temperature will result in a very large and entirely disproportionate decrease in the yield, while an increase in temperature over the critical temperature increases the yield only slightly.

### HORIZONTAL REVOLVING KILN TO HANDLE SPENT SHALE

It will be noticed the critical temperature for the recovery of nitrogen as ammonia gas is between the temperature required for the burning of cement clinker and the temperatures now found in the nitrogen re-

<sup>1</sup>CHEM. & MET. ENG., vol. 21, No. 4, p. 176.

<sup>2</sup>CHEM. & MET. ENG., vol. 22, No. 1, p. 20.

covery section of the Scotch dual purpose retort. It is therefore evident that the horizontal revolving kiln, as constructed for the burning of cement clinker, will be capable of handling spent shale.

#### FIXED CARBON IN SPENT SHALES

In all spent shale there remains some fixed carbon. This fixed carbon content may be as low as 2 per cent and as high as 25 per cent of the original shale. The quantity present in the spent shale will depend upon the treatment received by the shale during the process of distillation, and it must not be forgotten that during the distillation the weight of the shale is considerably reduced, the amount of reduction depending upon the richness of the shale. The percentage of fixed carbon in the spent shale will in most cases be largely increased, especially when the shale is rich.

To illustrate, certain shales upon analysis were found to contain fixed carbon in the following amounts: No. 1, 8 per cent; No. 2,  $5\frac{1}{2}$  per cent; No. 3,  $2\frac{1}{2}$  per cent. If through distillation no fixed carbon be lost, the spent shale would contain: No. 1,  $12\frac{1}{2}$  per cent; No. 2, 8 per cent, and No. 3, only  $3\frac{1}{2}$  per cent. The difference is of importance, because while it is evident that some shale may contain sufficient fixed carbon to produce, by itself, upon combustion, the temperatures required, other spent shales do not, and in such case the carbon in the shale will have to be supplemented by powdered coal, fuel oil, or gas. The question of fuel, therefore, may be in some cases the determining factor as to whether it would be profitable to recover by-products from the spent shale.

#### PROBABILITY OF PRODUCTION OF INCREASED QUANTITIES OF AMMONIA GASES

It would appear probable that spent shale burned at the correct temperature, in a horizontal revolving kiln, in the presence of low pressure superheated steam, will produce largely increased quantities of ammonia gases, and that such increase may exceed one-third of the present yields. The production will be helped by the fine crushing of the spent shale before burning, and this can be done at a low cost, because the spent shale possesses physical characteristics which will permit of its being easily crushed so that 98 per cent will pass through a 200 mesh, as is done with the "dry mix" from which portland cement is made. It should also be noted that with this preliminary crushing, and by the use of the kiln at the temperatures stated, it becomes possible to recover any potash that may be in the shale. When potash recovery is desired it may be necessary to increase the temperature, because it is stated (see page 130, R. K. Meade's "Portland Cement") that the whole of the volatile contents of the "dry mix" is "not driven off until the clinker is completely burned and about to leave the kiln," and that then less than 1 per cent remains. From this it is evident that for potash recovery a high temperature within the kiln is essential. It is fortunate that the high temperature so required will not interfere with the recovery of nitrogen.

#### OPPORTUNITY FOR PIONEER WORK ON POTASH IN SHALES

It is known that potash in economic quantities has been found present in some shales, but it has not been ascertained whether its presence is universal or even if, when its presence has been discovered, it persists

throughout the bed of shales in which it has been found. Much useful pioneer work might be done in this connection, now that an economical method of recovery is available.

#### METHOD FOR RECOVERY OF POTASH

The *modus operandi* for the complete process is as follows:

1. Eduction of oil contents of shale in retort expressly designed for that purpose.
2. Grinding of the spent shale so that 98 per cent will pass through a 200 mesh.
3. The ground spent shale is burned in a horizontal revolving kiln into which low pressure superheated steam is suitably introduced, the burning being obtained by the combustion of the contained carbon, supplemented, when required, by powdered coal, fuel oil, or fuel gas, but preferably fuel gas.
4. The fumes driven off are passed through a Cottrell dry separator, in which the dust and also certain portions of the potash are removed.
5. The fumes then pass through a specially constructed waste heat steam boiler, the product of which is low pressure steam, most of which is used in the kiln.
6. The fumes then pass to scrubbers, in which machines the remainder of the potash and the ammonia are recovered. The water from the scrubbers containing the potash and the ammonia is then treated with sulphuric acid, producing a salt which would make a very valuable chemical fertilizer.

#### PRODUCT IS A CONCENTRATED FERTILIZER

Though commercial mixed fertilizers are looked upon with disfavor by many, the above-mentioned mixture need not necessarily come under such strictures. As a concentrated fertilizer, in a form that is readily soluble, it would have much to commend its use.

It need hardly be pointed out that the Scotch dual purpose retort cannot provide the temperatures necessary either for a full recovery of the nitrogen or for the recovery of such potash as may be found, in commercial quantities, in some shales.

#### SPENT SHALES AS RAW MATERIAL FOR PORTLAND CEMENT

Lastly, it has been suggested that the spent shale could, in part, be used as raw material for the manufacture of portland cement. Mr. R. K. Meade in 1911 reported to the Canadian Government, page 25, Summary Report of Mines Branch of the Department of Mines, for year ending 1911: "These analyses indicate that satisfactory portland cement can be made from a combination of any one of the first three limestones and the residue from the oil-bearing shale," tested by him. Should it be desirable to produce portland cement and should the composition of the spent shale be found suitable for the production of portland cement, with or without the addition of lime to the spent shale, a comparatively small addition to the revolving kiln plant would make that part of this plant suitable for the manufacture, but it is possible, though by no means certain, that the requirements of such manufacture might be found to interfere with the recovery of the nitrogen.

In the plant as indicated there are the possibilities of great flexibility of operation. Such possibilities are entirely absent from the Scotch dual purpose retort, although, because it was a dual purpose retort, flexibility was a most important requisite.



# Electric-Resistance Furnace of Large Capacity for Zinc Ores\*

## I. Description of Furnaces and Process

Details of the Experimentation Work With Electric-Resistance Furnaces of Commercial Size Based on the Author's Well-Known Plan of Making Briquets With the Zinc Ore to Be Treated and Using These Briquets as Resistors for an Electric Furnace

BY CHARLES H. FULTON†

**E**XPERIMENTAL work on the process was begun on a laboratory scale at Cleveland, Ohio, in 1914, and transferred to East St. Louis, Ill., in 1916, where a commercial sized furnace was in technical operation until January, 1918. The essential steps are:

Oxidized zinc ore or roasted zinc concentrate is mixed with crushed coke and coal-tar pitch and formed into briquets 9.25 in. in diameter and 21 in. long in a manner similar to that used in the manufacture of graphite or carbon electrodes, except that much less care and time are required. The composition varies with the nature of the ore. These briquets maintain their form and volume during and after the distillation of the zinc. This object is gained by using coke as the matrix and coal-tar pitch as the binder; this pitch becomes coke on heating and unites the ore particle and the original coke particle into a continuous mass. The briquet is an electrical conductor, but only to such a degree that it can be used as a resistor.

The size of the ore, as in the present practice of zinc metallurgy, ranges from fine material, such as flotation concentrate, to coarse table and fine jig concentrate. The process is not restricted to any particular kind of ore, but is applicable to pure high-grade ores, ores high in iron, and complex zinc-lead ores, since the residue from the distillation is held immovably in place within the briquet. In the case of complex zinc-lead ores, the distillation is conducted with a carefully regulated temperature so that a high percentage of lead is retained in the distilled briquet, which may then be smelted for its lead content. In present zinc smelting practice, the reduction fuel is from 40 to 50 per cent of the weight of the ore. In the briquet, it is from 60 to 85 per cent of the ore; but unless the ore is exceptionally high in residue, the distilled briquet may be used over again as coke, or as a high-ash coke for fuel purposes in power production.

### SIZE OF BRIQUETS AND FURNACE CHARGE

Baked briquets are hard and tough and may be handled roughly without danger of breakage. In regular commercial work, they may be manufactured by means of extrusion on other suitable presses, after the manner in which electrodes are made, and the process be carried out continuously from the mixing to the finished briquet. The briquets weighed about 90 lb. and contained approximately 50 lb. of ore, which is about the amount in a retort charge in present zinc-smelting practice. It is proposed to make briquets 12 in. in diameter and 72 in. long, which will weigh about 600 lb.

On distillation, the briquets lose from 30 to 50 per cent of their weight, but maintain their form and volume. The zinc may be completely distilled from the briquet, traces only remaining, no matter what type of ore is used. The completeness of distillation is due to the intimate mixture of ore and reducing agent maintained throughout the operation.

The second step of the process consists in making the briquet a part of an electric circuit and heating the same by an electric current to such a degree that the zinc is distilled. During this operation, the briquet is covered by a movable retort and the zinc vapor and carbon monoxide are conducted to a condenser in which the zinc is condensed. During the distillation, the briquet acts as a continuous resistor and maintains itself unaltered between the terminal electrodes. As the furnace is not limited to the interposition of one briquet between the terminal electrodes, a large number may be interposed, thus giving a large unit furnace. While direct current may be used, alternating current is preferable on account of the ease of voltage control by means of transformers. The furnace of East St. Louis held a charge of 36 briquets, arranged in twelve columns of three each, set within a circle and operated on a three-phase circuit,



FIG. 1. SET UP BRIQUET CHARGE  
Column 9.25 in. diam., 66 in. high, 12 columns. A, Bottom graphite connector blocks; C, Special fireclay base; D, Top Graphite connector blocks; E, Graphite disks.

\*A paper read at the Chicago meeting of the American Institute of Mining and Metallurgical Engineers, Sept. 24, 1919.

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four columns in each phase, connected in the customary Y connection. The amount of charge in this furnace varied between 3100 and 3200 lb, the amount of ore being approximately 1700 lb. The time of distillation was about 6 hr.; the total time, including the placing and discharging, was 8 hr., or three charges worked off in 24 hr. The capacity of the furnace was 5100 lb. of zinc concentrate per 24 hr. A proposed larger furnace, taking nineteen briquets weighing 600 lb. each, will have a capacity of about 8.5 tons of zinc concentrate per retort per 24 hours.

#### EARLY EXPERIMENTAL WORK

Experimental work was begun at the Case School of Applied Science, in Cleveland, in May, 1914, for the production of a zinc-ore briquet from which the zinc could be practically completely distilled, and leave the briquet of the same volume and shape as before distillation. The experiments were carried on with all sizes of briquets ranging from 1 in. in diameter and 1 in. long up to 9 in. in diameter and 20 in. long, and with spherical briquets up to 8.5 in. in diameter. Satisfactory briquets were made from practically every type of zinc-bearing material.

The "indestructible briquet" was intended for an automatic externally fired furnace,<sup>1</sup> but in 1915 experiments were begun using the briquet as the resistor. The first briquets were 1 in. in diameter and 1 in. long, but later the briquets were 3 in. in diameter and 4 in. long; the furnace held from 48 to 56 arranged in eight columns 6 or 7 briquets high, set up very much in the manner shown in Fig. 1 and operated in one continuous circuit. At first, direct current was used; later, alternating current. The distillation, in almost every instance, could be carried to completion, even with the many electrical contacts in the furnace, demonstrating that the indestructible briquet made a perfect resistor if properly made. On the basis of this work the East St. Louis plant was planned, not as a commercial plant, but as an experimental plant for the purpose of working out the technical details of a commercially sized furnace.

#### THE BRIQUET

The briquet must form an intimate mixture of the roasted ore, reducing agent, and binder. A particle of ore should be in contact with a particle of reducing agent and both should be surrounded with a film of binder to unite all the particles into a coherent mass. In known applications of briquetting to ores, the briquet is destroyed during the operation that extracts the metal. In this particular case, the briquet must preserve its form and be practically of the same volume after the extraction of the metal as it was before in order to maintain passage of the electrical current. If the briquet should collapse during the distillation process, the furnace would become inoperative. Another advantage of the indestructible nature of the briquet, in the case of such ores as lead-zinc, zinc-copper, or franklinite, is that the residue is in the form best suited for further metallurgical treatment.

The briquets are made with an excess of the reducing agent, coke, so that after distillation there will remain sufficient matter to maintain the original volume of the briquet. In general this condition is obtained if the weight of the distilled briquet is not less than 40 to 50 per cent of the original briquet.

Zinc ores and zinc-bearing materials differ widely in the nature and amount of mineral residue left after the distillation of the zinc, as shown in Table I. The nature and amount of the residue left by the ore have great influence on the stability of the briquet during and after distillation.

TABLE I. AMOUNT OF MINERAL RESIDUE IN ZINC ORE

Name of Ore	Per cent of Residue, by Weight	Character of Residue
Mascot, Tennessee.....	12.5	Largely silica with a little iron oxide.
Wisconsin ore, No. 1.....	15.8	Largely iron oxide, some silica.
Wisconsin ore, No. 2.....	18.3	Same as above.
Missouri ore.....	20.9	Largely iron oxide, some silica.
Canyon City, concentrate.....	27.9	Mostly iron oxide and silica.
Willemite zinc ore, from Franklin Furnace, N. J.....	36.7	Mostly silica.
Franklinite zinc ore, Franklin Furnace, N. J.....	55.58	Chiefly iron and manganese oxides.
Zinc dust, zinc oxide.....	None	

#### COKE CONTENTS OF BRIQUET

Enough coke must be added to the ore to furnish the necessary carbon for the reduction of all the reducible oxides in the ore, plus such an amount that the weight of the briquet, after distillation, will be not less than 40 to 50 per cent of the original briquet. Ores that leave a small amount of residue require more coke than ores that leave much residue. As the briquet must at all times be an electric conductor, there must always be present sufficient carbon in the coke, by which the current is chiefly carried.

The nature of the residue also is of great importance. If the residue is siliceous in character, like that of the willemite, which after distillation is in the form of comparatively sharp angular grains fused only on the edges, less coke is needed for a strong briquet than if the residue is of the nature left by franklinite, which is in the form of round fused globules. The sharp angular grains are bound into a suitable network with the coke grains, while the round fused globules must be held by the coke skeleton and in themselves give no strength to the structure they are part of. In the case of franklinite, the residue consists largely of small globules of an iron manganese alloy, which aids in the conductivity of the mass; in the case of willemite, the siliceous residue is a non-conductor.

From the standpoint of non-conductivity, a lime residue is most objectionable, as, under certain circumstances, this lime will form calcium carbide with the briquet, giving rise to high resistance. An ore containing a high lime residue will make an excellent briquet that will act normally in the furnace until a certain temperature is reached, after which, due to the combination of lime and carbon, the resistance will increase and the briquet become locally overheated and break down. This difficulty can be overcome by an extra amount of coke. The proper amount of coke for different types of ores is, approximately, as follows:

	Per Cent of Weight of Ore
Willemite <sup>2</sup> .....	30 to 40
Franklinite.....	70 to 80
Pure Mascot ore.....	70 to 75
Canyon City ore.....	60 to 70
Missouri silicate ore.....	85
Zinc dust.....	70

#### PITCH CONTENT OF BRIQUET

The grains of ore and coke must be surrounded by a film of binder, which should have an appreciable thick-

<sup>2</sup>This proportion makes a strong briquet that will withstand distillation in an externally fired retort, but for electrical distillation the coke must be increased.

<sup>1</sup>D. B. Jones, U. S. Patent No. 1,292,330.



ness. As the binder must cover a certain amount of surface, the smaller the ore and coke particles the greater is the surface to be covered; therefore the amount of binder varies directly with the fineness of the ore and coke. By experiment it was found that a satisfactory briquet can be made if the amount of binder is between 10 and 15 per cent of the weight of the ore plus coke. More binder than this is detrimental, as the excess will be squeezed from the briquet during pressing; less, in most cases, will not give a satisfactory briquet. The percentages given apply to moderately fine ore, such as will pass through a 65-mesh screen, and to moderately fine coke, such as will pass through a 10-mesh screen. If the zinc-bearing material is excessively fine, as for instance zinc oxide or leaded zinc oxide, more binder must be used.

#### SIZE OF ORE PARTICLES

Within certain limits, the size of the ore has relatively little influence on the final strength of the briquet; neither has it much influence on the rate of distillation of zinc from the briquet or the completeness with which the zinc is extracted. Ore that passes through a 10-mesh screen and 86 per cent of which is coarser than a 35 screen gives practically no different result from ore all of which passes through a 200-mesh screen. Usually the material furnished the zinc smelter is comparatively fine and sometimes is very fine. Experiments with material coarser than 8-mesh have not been made. The ore or concentrate usually is made up of particles ranging in size from approximately  $\frac{1}{16}$  in. down to an extremely small size. This mixture is an advantage, although good briquets can be made from very fine ore. In the case of ores that give a fused residue in the form of little pellets or globules, as for instance franklinite, the coarser ore does not give as good results as the fine ore, as the first gives opportunity for these fused globules to segregate and coalesce within the briquet. Small globules are more permanently held in place by the coke skeleton. The size of ore particles has such little influence on the ultimate stability of the briquets because the particle is practically destroyed during distillation, since it loses in the case of most zinc ores by far the greater part of its weight.

#### SIZE OF COKE PARTICLES

The size of the coke particle has a very decided influence on the strength of the briquet. Very fine coke gives a much stronger briquet than moderately fine or comparatively coarse coke. For example, a cylindrical franklinite briquet, 3 in. in diameter, 4 in. high, made with 100 parts ore, 70 parts coke, and 20 parts pitch, but in each case with different sizes of coke, had the following crushing strengths: 20-mesh, 15 lb. per sq.in.; 48-mesh, 200 lb. per sq.in.; 100-mesh, 610 lb. per sq.in. When it is desired to obtain an especially strong briquet, relatively fine coke should be used. However, as the coke increases in fineness and fine ore is used, the amount of binder will increase, which is undesirable from a commercial standpoint.

#### CHARACTER OF COKE USED

The coke used must be firm and hard, not soft and spongy. It should have a relatively low ash content, particularly if it is used with ore containing much residue. If it is to be used with relatively pure ore, or with blue powder, the ash content may be high. Good, screened coke breeze, such as gashouse breeze

or by-product oven breeze, is suitable if the ash content is not too high.

#### CHARACTER OF PITCH USED

The character of the coal-tar pitch used is all important. The chief points to be noted are the character of the coke left after the distillation of the volatile matter, the percentage of coke remaining after distillation, and the melting point of the pitch. In general, a high melting-point pitch, 170 to 200 deg. C., leaving a high percentage, 55 to 60, of good firm coke is best. Since the briquet is molded hot and is taken from the mold while warm, it is weak, and the lower the melting point of the pitch the weaker is the briquet. A briquet made with a high melting-point pitch is quite strong and stands handling when taken from the mold.

High melting-point pitches obtained by mixing rather low melting-point pitch with fine amorphous carbon will yield a high percentage of coke, but they are weak and do not give good, permanent binding properties; neither have they good initial binding properties.

#### METHODS OF MAKING BRIQUETS

A number of methods may be used for making briquets. The first method used in the experimental work was to thoroughly mix the coke, ore, and pitch (in powdered form) and heat this mixture, on a large hot plate, to between 175 and 200 deg. C., or until yellow fumes appeared from the pitch, when it is granular and somewhat plastic, but not sticky. It was then molded in cylindrical steel molds, with a slight taper, the material being compressed by means of a steel plunger, the bottom of the mold being closed with a small disk to hold the material in place. The pressure varied between 500 and 1000 lb. per sq.in. For the best results the mold should have a temperature between 75 and 90 deg. C. when a high melting-point pitch is used. Under these conditions the briquet will come from the mold with a smooth exterior and sharp edges. The briquet, immediately after expulsion from the mold, is somewhat weak, but becomes strong and firm on cooling.

The second method, used for making briquets 9.25 in. in diameter by 22 in. long, employed at the East St. Louis plant, is as follows: The ore and coke in proper proportions are thoroughly mixed, slightly damp, in a knife-blade mixer and then stored in bins and fed as needed to a Bartlett-Snow kiln drier, provided with plows. Here it was heated to about 250 deg. C. and discharged into a hopper at the end of the drier, from which it was drawn into a hopper car in lots of approximately 500 lb. This hopper was picked up by the crane and discharged into the knife-blade mixer, where the proper amount of molten pitch was immediately added and the contents mixed for 3 to 5 min., after which the mixture was discharged into a small, flat, brick-lined car kept at a temperature of about 250 deg. C. This car was transferred to the tamping machine, made of a 3.25-in. Ingersoll rock drill.

The tamping tool was a three-arm steel casting provided with cylindrical steel teeth 3 in. long, which were replaced when necessary. The arms of the tamping tool freely cleared the sides of the mold, which was made of heavy cast steel, in three parts longitudinally, the parts being held together, during molding, by hinged bolts fitting into slots. A specially shaped heavy steel base plate under the tamping machine insured a constant

and fixed position of the mold during tamping. The bottom of the mold was closed by a steel disk 1.5 in. thick, which was set in a circular depression 1 in. deep in the steel base plate, causing the disk to project about 1 in. below the bottom of the mold while the walls of the mold rest on the base plate. The mold was then tamped nearly full of the mixture, which at the molding place has a temperature of 160 to 175 deg. C. The mixture was fed into the mold by a long narrow scoop shovel and tamped in, the tamping

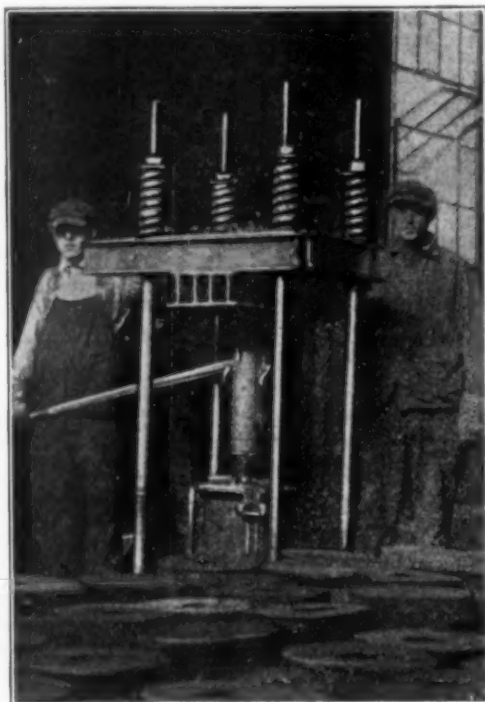


FIG. 2. BRIQUET PRESS

and feeding being simultaneous. As the mold filled, the tamping tool was raised by the feed device of the rock drill.

The mold and its contents were then transferred to the adjacent finishing press, which was made from a railroad jack and used in the inverted position (see Fig. 2). A special plate under the jack permitted the mold to be placed accurately in position. The remaining space in the mold was filled with the mixture, a top steel disk put into place, and the contents of the mold compressed until the pressure reached 1000 lb. per sq.in., the pressure being determined by the contraction of the springs of the press. The weight of the mold and its contents, as it was placed under the press, rested on the bottom disk, which projected about 1 in. below the bottom of the mold. By this means both top and bottom pressure were obtained, which is preferable to pressure being applied from the top only. After the pressing, the bolts holding the mold together were slid out of place and the parts of the mold removed from the briquet, which was then placed on a car, where it is allowed to cool and become firm.

Small briquets have also been made on a laboratory scale by the method of "cold mixing." The ore and coke are mixed with powdered pitch and then moistened with zinc-sulphate solution and pressed into briquets. A typical mix is represented by 100 parts ore, 70 parts coke, 20 parts powdered pitch, and 20 parts of 5 per cent zinc-sulphate solution. These briquets are fairly strong as they come from the mold and on baking

become very firm. It is questionable whether they are as good as the hot molded briquets, and the method has not been tried on a large scale.

#### SUBSTITUTING COAL FOR COKE

The base of the briquets is coke, but briquets have been made by replacing coke with coking coal, the idea being that the coking coal will furnish the carbon necessary for reduction and the excess required, as well as the binding effect of the pitch. Such briquets, however, require some binder and, after baking, are shrunk and warped; for this reason they cannot successfully be used in the electric furnace. The replacement of pitch by coking coal, if it were possible, would materially cheapen the briquetting process.

Briquets have also been made with anthracite coal, which were excellent from the standpoint of strength and non-warping quality; these briquets, however, do not become conductors of the electric current until a high temperature is reached, about 1150 deg. C. This requires too great a degree of preheating. Ordinary coke briquets are conductors at 500 deg. C.

#### REPLACING PITCH WITH COAL

Pitch in the briquet may be partly replaced by coking coal with good results. For instance, a mix made of 100 parts ore, 50 parts of 10-mesh coke, 40 parts of 80-mesh Pocohontas coking coal, and 10 parts powdered pitch, and one made of 100 parts of ore, 25 parts of coke, 70 parts of Pocohontas coking coal, and 10 parts of powdered pitch made good briquets after baking and gave good results on distillation. These briquets are made on the theory of replacing part of the coke and part of the pitch by coking coal, the coal acting as a binder and furnishing a part of the carbon; by this means the quantity of pitch required is reduced one-half. The proportions of coke and coal are calculated so as to leave the proper amount of excess carbon, taking into consideration the volatile matter of the coal. However, one serious objection to the use of any appreciable amount of coking coal is the fact that the products of the distillation of the coal are objectionable during the distillation of the zinc, and the relatively small saving of cost gained by its employment may be more than counterbalanced by the increased difficulties of condensation.

#### BAKING THE BRIQUETS

The purpose of baking the briquets is to coke the pitch; the temperature required to do this varies somewhat with the time of baking. For a 9.25- by 22-in. briquet, a baking period of 6 hr., and 500 deg. C. for 2 hr. near the finish, is about equivalent to a baking period of 8 hr. with a temperature of 450 deg. C. for the last few hours of the operation. The briquets must be kept from oxidizing during the baking; that is, they must be under neutral or reducing conditions. Baked briquets have a density of 98 to 115 lb. per cu.ft. dependent on the ore and on the proportions of the mixture.

At the East St. Louis plant, the briquets to be baked were stood on end on platform cars holding twenty briquets. Each briquet was set within a light sheet-iron cylinder 12 in. in diameter and 26 in. high, and the space between the briquets and the cylinders was filled with crushed coke. The car was then placed in one of the ovens, which formed part of the drier. The two ovens were near the head of the drier, which



was the firing end. The products of combustion passed both over and below the baking oven by specially constructed flues. When a load of briquets had been baked, the car was withdrawn and replaced by another. The period of baking was about 7 hr., and the maximum temperature reached at the end approximately 500 deg. C. A briquet that has been baked for the proper length of time at from 450 to 500 deg. C. is very hard and firm and may be thrown violently from the car to the floor while hot without injury.

The briquet during the baking passes through a weak stage, which is due to the condition of the pitch and continues during the baking until a temperature of about 300 deg. is reached. From this temperature up to 500 deg., there is a constant increase in strength as the pitch becomes coke. It would be desirable to eliminate the baking of the briquets as a separate operation and conduct the process by placing the raw briquets on the furnace base and do the baking as part of the furnace operation. In the operation of the furnace, the highly heated retort from a finished charge is transferred by the crane to the new charge on the second base. The heat stored in the retort is sufficient to bake a charge of raw briquets, but the weight of a column of briquets is such that the bottom briquet of the column will collapse in the weak stage. When the rate of heating is very rapid, a hard shell is formed on the briquet's exterior columns of the furnace charge immediately adjacent to the hot retort walls before the interior becomes sufficiently heated to be weak; this shell will sustain the briquet during the critical stage. The interior columns of the charge, however, are heated more gradually from the retort walls and do not form the hard shell, therefore they will collapse at the critical stage. It may be possible, under certain circumstances, to make a briquet that will not have to be baked in a separate operation.

#### RESISTIVITY OF BRIQUETS

The resistivity of hot briquets (900 to 1100 deg. C.) depends on the amount of coke used and the nature of the residue of the ore; it will range from 0.015 to 0.04 ohm per cu.in. The resistivity of the raw briquet is very high (26 to 30 ohms per cu.in.). This resistivity drops slowly until the pitch is coked at about 450 to 500 deg. C., when there is a sudden sharp drop to 0.6 to 0.7 ohm per cu.in. Fig. 3 shows a typical resistivity curve of distilling briquets.

Briquets made from ore, coke, and pitch become practical conductors at between 450 and 500 deg. C. Briquets in which part of the coke is replaced by bituminous coal do not become conductors until a temperature of 620 to 750 deg. C. is reached, depending on the proportion of coal used. Briquets where the coke is replaced by anthracite do not become conductors until about 1150 deg. C. is reached. This is too high for the proper working of the process, for the briquet would have to be reheated, even after baking, to this temperature by means of retort before the electric current would pass, and 1150 deg. C. is the temperature at which distillation is very active.

#### THE EAST ST. LOUIS PLANT

The large-scale experimental work was carried out in specially erected buildings in East St. Louis, Ill.<sup>2</sup> The main building and annex thereto were constructed of

steel and tile, the main building being of sufficient height to permit of the operation of a 12-ton electric crane for the lifting of retorts and the handling of materials. The annex contained a small, complete machine shop, and part of the electric equipment. A separate small wooden building was provided for an experimental laboratory, and contained the small testing furnaces and the chemical laboratory. There were also bins and storage sheds for ores, coke, pitch and general supplies.

In one end of the main building was placed the coke crushing plant, consisting of a 7-in. and 10-in. Blake crusher, a 20- by 12-in. set of rolls, an inclined screen, and a return bucket elevator. Adjoining the crushing plant was a Bartlett & Snow kiln drier, which dried ore and coke, heated the ore-coke mixture, and contained two ovens for baking briquets. This drier was fired at one end by an oil burner. The drier was

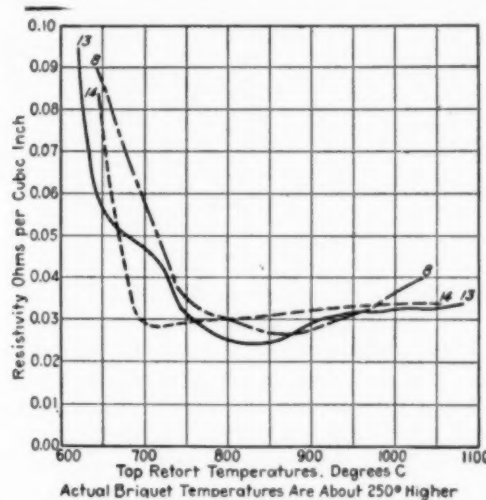


FIG. 3. RESISTIVITY CURVE OF DISTILLING BRIQUETS

especially designed as regards the setting and served the various purposes indicated. In a commercially operated plant the drying, heating, and baking would be done in separate apparatus. Adjoining the drier was the knife-blade mixer and the pitch melting kettle. Adjoining these was the tamping machine, briquet press, and tracks for the various transfer and platform cars for baking briquets. The rest of the space in the building contained the electric furnaces, the main transformers, and other electrical equipment.

#### FURNACE C

Furnace C is the designation applied to the first furnace built. It consists of a specially constructed three-part firebrick base, the center part holding the condenser structure, and the end parts containing the electrodes and serving to support the briquet charge and the covering retort. Figs. 4 and 5 show the features of construction.

The briquet charge was set up on the left-hand base *b*, Fig. 4, the retort *a* lowered into place by the crane, the current turned, and the charge distilled. In the meantime another charge was set up on the right-hand base *c*; when the left charge was finished, the red-hot retort was immediately transferred to the right-hand base and this charge distilled. While the second charge was distilling the spent briquets on the left-hand base were removed and a new charge set up, and the operation repeated. Oil burners were provided at four places under the vapor boxes *o*, the products of com-

<sup>2</sup>See "Fulton's Electric Zinc Furnace," MET. & CHEM. ENG., vol. 18, p. 539 (May 15, 1918); also vol. 16, p. 158 (Feb. 1, 1917).

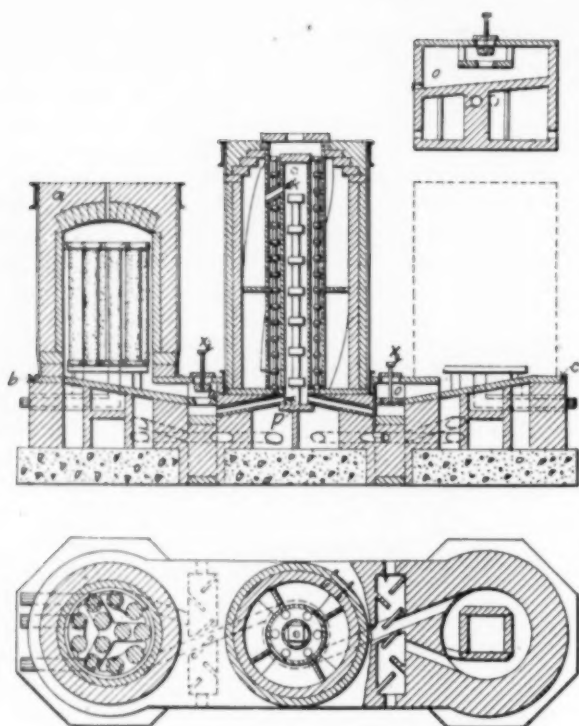


FIG. 4. FURNACE C

bustion from two of these burners passing by flues under the electrode supports in the retort bases, thence through the central flue in the condenser structure, to the air. The products of combustion from the other two burners passed from under the vapor boxes directly to the central flue of the condenser. The idea was to preheat the retort bases and the condenser to the proper temperature for the distilling operation and prevent the formation of blue powder in the condenser at the start.

The necessity for proper temperature conditions for successful spelter condensation in the condenser were fully recognized. In case radiation from the condenser walls should be insufficient to maintain proper temperature conditions within the condenser during the continuous operation of the furnace, due to the heat involved by the condensation of the large volumes of zinc vapor, the heating flues could be turned into cooling flues by the shutting off of the oil burners and closing the two retort base flues. The volume and surface of the condenser were designed on the basis of the relation of these factors to the amount of vapor, as found in the present-day retort and condenser of the standard zinc-distilling furnace. The condenser was provided with three platinum-rhodium thermocouples, one at the top and one at the bottom of the central chamber *p* (Fig. 4), and one at the bottom of the outer annular chamber. The retort was provided with two pyrometers, embedded with the refractory lining within  $\frac{1}{2}$  in. of the interior surface, one at the top and one at the bottom. The readings of the retort pyrometers were about 250 to 300 deg. C. below the actual briquet temperature but, with this correction known, these readings served as a perfect guide in the operation of the furnace.

#### DETAILS OF CONSTRUCTION

The retort consisted of a 0.25-in. steel shell stiffened at the top by a 12-in. channel, to which were bolted heavy cast-steel hooks, which engaged the chains of the bail by means of which the retort was lifted by the

crane. The bottom of the shell was drawn in 1 in. and then flanged outward for stiffening; the contraction was for the purpose of holding the refractory lining firmly in place. The bottom of the lining was a circle of firebrick blocks 9 in. high and 13.5 in. wide, the full thickness of the lining. On these was built the interior lining of high-grade firebrick, 4.5 in. thick, the space between these and the steel shell being filled with 9-in. sil-o-cel brick and loose sil-o-cel. The roof was a firebrick dome, covered with loose sil-o-cel. The interior diameter was 48 in., and the interior height from the base to the lowest point of the dome was 72 in. The clearance between the briquet columns and the lining of the retort was 2.5 in. The clearance between the columns was about 2 in.

The electrode construction is shown in Figs. 6 and 7. Four graphite electrodes *F*, Fig. 7, 6 in. square and finished to cylindrical ends for the attachment of the electrode holders *G* passed into the furnace base through the opening *E*. On these electrodes were set 6-in. graphite risers, which reach the level of the furnace base through the openings *A*, Fig. 6. These plugs were later replaced with 9-in. plugs. A seal was made by filling in the space between the plugs and the walls of the openings with finely crushed carbon. In the first operation of the furnace, a special firebrick block was set on the base of the furnace, as shown at *C*, Fig. 1, through which the vertical plugs passed to make contact with the graphite blocks *A*, on which the columns of briquets were set. The purpose of this firebrick was to prevent a short circuit in the case of a condensation of zinc on a cool base. It was found unnecessary, so the graphite blocks *A* were set directly on the base in contact with the vertical riser plugs.

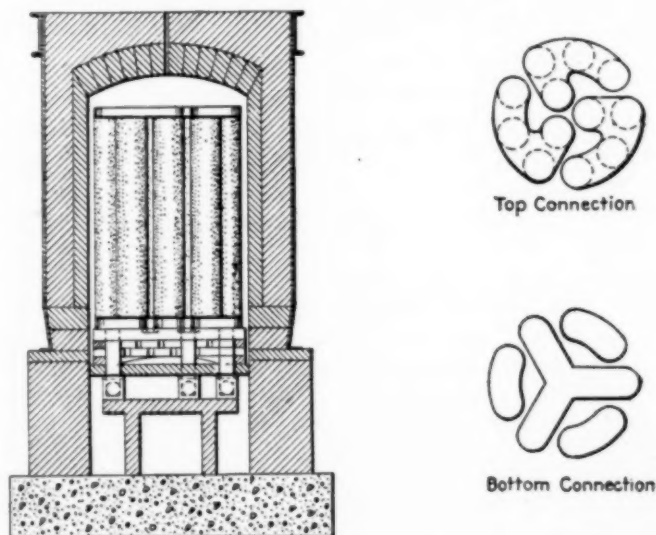


FIG. 5. FURNACE C

The top connections are also made by 5-in. graphite blocks *D*, as shown in Fig. 1. Fig. 5 shows the arrangement of the bottom blocks and of the top blocks on the "Y" connection. As shown in Figs. 6 and 7, the furnace has four electrodes. One of these is the neutral, which is brought to the exterior of the furnace to provide for an extra connection in case of a breakdown.

In order to insure perfect contact between briquets, a paste consisting of 50 parts tar oil and 35 parts of finely ground graphite was rapidly applied, hot, to the ends of the briquets by a stiff broad brush or a trowel. It had excellent adhesive properties and when



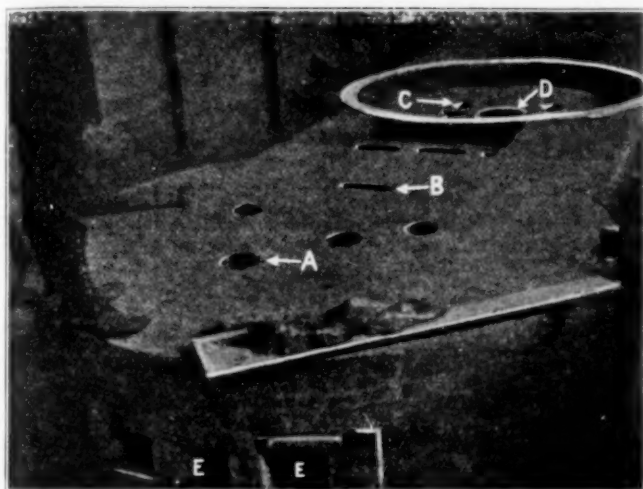


FIG. 6. BASE OF FURNACE C

baked was as good a conductor as the briquet, or better. A number of charges built up of whole briquets and briquets broken into a number of pieces, making numerous contacts with the use of this material, passed through the distillation perfectly. This is a very severe test of the process from an electrical standpoint.

#### ELECTRICAL EQUIPMENT

The electrical equipment for furnaces designated as C, D, and E was the same, and consisted of a General Electric 150-kw., three-phase transformer and a poly-phase induction regulator. Sixty cycle current at 1300 volts was stepped down to 220 volts by transformers outside of the building and passed to the regulator placed in one corner of the main structure. From this, cables in underground conduits led to the transformer pits located at the end of each retort base. The transformer was placed in this pit and connected to the primary cables from the regulator and the secondary leads of the transformer to the furnace electrodes. When a charge was distilled, the connections were broken and the transformer lifted by the crane and transferred to the pit at the other retort base. The secondary terminals of the transformer were brought out to a terminal board attached to the transformer and were so arranged by means of heavy copper links, which could be rapidly changed in position, that the three main secondary taps leading to the electrodes of the furnace by heavy flexible

cables could be at voltages of 27.5, 55, 110, and 220. By means of the regulator, the voltage adjustment between these ranges was practically continuous and a maximum voltage of 262 and a minimum of 22.5 could be obtained with a primary line voltage of 220. The power company employed boosters on its line so that a line voltage of 300 volts was sometimes available. The voltage at the electrodes with the Y set up was, when beginning operations with a cold charge, sometimes as high as 300. With hot retorts, however, the voltage would be about 150 at the start, with an energy input of 120 to 150 kw., and lowered to from 75 to 90, and the energy input used was from 122 to 184, the latter for only short periods of time, as this intensity overloaded the transformer. The electrical equipment was somewhat under capacity and the furnaces could easily take 200 to 250 kw., as was demonstrated later with new equipment on furnace F. The low kilowatt input for furnaces C, D, and E accounts for the somewhat higher distillation periods (more than 8 hr.) and also the larger power consumption, due to increased radiation losses on account of the unnecessarily long time. All electrical instruments and switches were located in the shop annex, and the furnace was electrically operated from this place.

(Part II, dealing with the operation of the furnaces and general characteristics of the process, will be published in our next issue.)

#### Sulphur to Compete With Iron Pyrites

Changed conditions since the war will bring about very shortly the substitution of brimstone for much of the sulphur which heretofore has been recovered from iron pyrites, it is believed in Washington. The amount of labor with its attending cost, which must be expended in the mining and treatment of pyrites is the more important factor contributing to the change. The high transportation rate is also a factor, especially in the case of pyrites imported from Spain.

On the other hand, the mining of sulphur by the Frasch process requires a much smaller proportionate expenditure for labor. The erection of the large plant on the newly opened sulphur deposits at Matagorda, Tex., as well as the large capital expenditures represented by the plants in Calcasieu parish, La., and at Freeport, Tex., is expected to necessitate the operation of these properties. It is believed that the pure sulphur from these sources can be sold from this time on in successful competition with pyrites.

It has been in the past the attitude of the Union Sulphur Co., which operates the Louisiana properties, to restrict its sales of sulphur to the industries requiring high-grade material. That company never has shown a disposition to enter the field where the lower-grade material has sufficed as well. In this stand the company has had the encouragement of the United States Geological Survey. There always has been much uncertainty as to the reserves of pure sulphur, and it has been a very general desire to safeguard this material against future needs. The development of seemingly very large sulphur deposits in Texas and the fact that no signs of exhaustion are appearing in Louisiana, despite the enormous output, are tending to overthrow efforts to reserve this sulphur for the higher class uses. In addition, there is the important economic question of securing a return on the money invested in these sulphur properties.

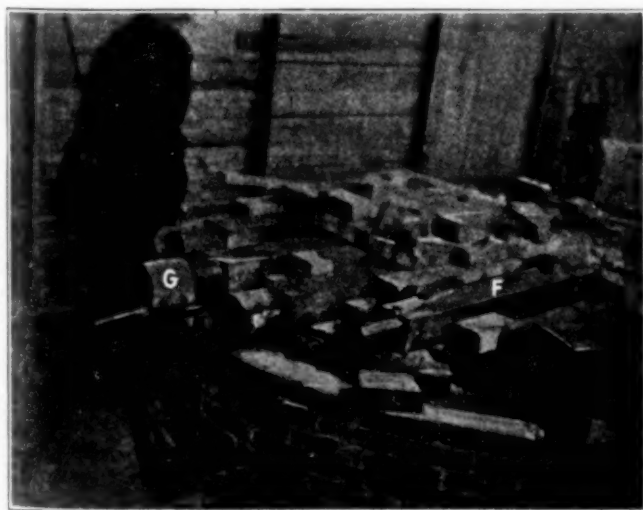


FIG. 7. ELECTRODE CONSTRUCTION FURNACE C

## Fusibility of Coal Ash From Eastern Coals\*

BY W. A. SELVIG, O. C. BROWN AND A. C. FIELDNER

THE Eastern coal province, which includes the anthracite regions of Pennsylvania and Rhode Island, the Atlantic coast region of Virginia and North Carolina, and the great Appalachian region, contains the best known and most extensively mined coals in the United States.

Previous papers<sup>1</sup> gave a description of the standard gas furnace method used by the Bureau of Mines in

\*Published by permission of the Director, U. S. Bureau of Mines. <sup>1</sup>Selvig, W. A., "Fusibility of Coal Ash From West Virginia Coals," CHEM. & MET. ENG., vol. 19, No. 12, 1918, pp. 826-828.

Selvig, W. A., and Fieldner, A. C., "Fusibility of Ash From Pennsylvania Coals," CHEM. & MET. ENG., vol. 20, No. 12, 1919, p. 629.

Selvig, W. A., Ratliff, W. C., and Fieldner, A. C., "Fusibility of Coal Ash," CHEM. & MET. ENG., vol. 20, No. 6, 1919, pp. 274-276.

For complete tables giving results obtained for each mine tested see: Selvig, W. A., "Fusibility of West Virginia Coal Ash," *Coal Age*, vol. 15, No. 1, 1919, pp. 12-16; Selvig, W. A., and Fieldner, A. C., "Fusibility of Ash From Pennsylvania Coals," *Coal Age*, vol. 15, No. 24, 1919, pp. 1086-1089; Selvig, W. A., Ratliff, W. C., and Fieldner, A. C., "Fusibility of Ash From Coals Found in the Interior Province," *Coal Age*, vol. 15, No. 16, 1919, pp. 698-703.

making ash fusibility tests, a discussion of the relation of fusibility tests to clinker formation, and tables giving results obtained for West Virginia, Pennsylvania and Mid-Continent coals.

This paper includes a table giving the results obtained for all coals tested from the remaining States of the Eastern coal province and includes coal from Ohio, eastern Kentucky, Virginia, Maryland, Tennessee and Alabama.

No coals from Rhode Island, North Carolina or Georgia are represented. The States of Rhode Island and North Carolina are of little commercial importance as coal producers.

### INTERPRETATION OF FUSIBILITY TABLE

The samples represented are standard mine samples collected by representatives of the Bureau of Mines, the U. S. Geological Survey, or by the various State Geological Surveys, according to the methods used by the Bureau of Mines.<sup>2</sup>

<sup>2</sup>Holmes, J. A., "The Sampling of Coal in the Mine," Technical Paper 1, Bureau of Mines, 1911, 18 pp.

FUSIBILITY OF COAL ASH FROM EASTERN COALS

State, Bed	No. Mines Sampled	Total No. Samples	Av. Softening Temp. Deg. F.	Ash in Dry Coal, Per Cent.	Sulphur in Dry Coal, Per Cent.	State, Bed	No. Mines Sampled	Total No. Samples	Av. Softening Temp. Deg. F.	Ash in Dry Coal, Per Cent.	Sulphur in Dry Coal, Per Cent.
<b>OHIO</b>						<b>MARYLAND</b>					
Anderson (Bakerstown) Bed.	1	1	2120	10.86	3.92	Bakerstown Bed.	5	5	+2560	10.26	1.70
Lower Freeport Bed.	8	16	2280	9.55	2.95	Bluebaugh Bed.	3	3	+2770	12.99	1.63
Lower Kittanning Bed.	4	4	2120	9.24	5.72	Brush Creek Bed.	1	1	2470	9.61	1.26
Mahoning Bed.	1	1	2040	6.59	3.67	Clarion (Parker) Bed.	2	2	2280	9.61	2.42
Meigs Creek (Sewickley) Bed	5	5	2330	13.02	4.23	Franklin Bed.	1	1	2410	8.48	1.36
Middle Kittanning Bed.	6	6	2450	8.00	1.86	Gallitsen Bed.	3	3	2140	12.15	3.33
Pittsburgh (No. 6) Bed.	10	14	2210	8.47	3.58	Grantsville Bed.	1	1	2490	8.23	1.22
Uniontown Bed.	2	2	2230	16.10	3.58	Little Pittsburgh Bed.	1	1	+3010	7.95	1.18
Upper Freeport (No. 7) Bed.	10	14	2280	8.48	3.09	Lower Freeport Bed.	1	1	2150	20.51	4.11
Washington Bed.	1	1	2520	21.90	2.98	Lower Kittanning Bed.	15	24	2440	10.76	2.26
Waynesburg Bed.	4	4	2400	15.92	3.15	Merced (Mount Savage) Bed.	3	3	+2620	18.14	3.28
<b>EASTERN KENTUCKY</b>						Pittsburgh (Big) Bed.	6	20	+2930	7.67	1.03
Alum Bed.	1	1	2940	4.37	0.61	Quakertown Bed.	1	1	+3010	17.03	2.92
Elkhorn Bed.	8	22	2470	3.83	0.68	Split-six Bed.	1	1	2220	12.42	2.55
Fire Clay (Dean or No. 4) Bed	9	25	+2790	5.35	0.82	Upper Freeport Bed.	5	5	2500	10.72	2.03
Flag (No. 7) Bed.	1	4	2880	7.52	0.83	Upper Kittanning Bed.	2	2	+3010	9.50	0.86
Harlan Bed.	3	8	+2700	3.94	0.85	Upper Sewickley (Tyson) Bed	6	9	+2840	6.65	1.09
Hazard (Haddix or No. 6) Bed	1	4	2460	8.56	0.79	Waynesburg Bed.	1	1	2410	13.75	2.58
Hickory Bed.	1	4	2340	5.37	1.07	<b>ALABAMA</b>					
Jellico Bed.	1	4	2460	6.92	1.56	Black Creek Bed.	3	12	2530	3.31	0.83
Kellioka (C) Bed.	1	1	2230	2.21	0.49	Clark Bed.	2	6	2350	8.68	1.06
Lower Bolling Bed.	1	1	2880	11.65	1.01	Coal City Bed.	1	3	2250	4.35	1.10
Lower Hignite Bed.	1	3	2440	4.57	1.10	Gholson Bed.	2	7	2240	6.64	0.73
Lower Standiford Bed.	1	1	2260	5.24	1.81	Harkness Bed.	3	8	2460	11.51	1.57
Mason Bed.	3	11	2320	3.93	1.14	Helena Bed.	2	6	2420	8.91	0.46
Miller Creek (No. 1) Bed.	6	13	2160	4.23	1.90	Jagger Bed.	3	8	2690	9.81	0.67
Poplar Lick Bed.	1	4	2670	5.30	1.05	Jefferson Bed.	1	4	2120	7.45	2.80
Rawl (Gas or No. 2) Bed.	2	2	+2680	7.53	1.90	Mary Lee (Big) Bed.	4	14	2830	9.90	0.74
Straight Creek Bed.	4	16	2110	3.40	1.17	Maylene Bed.	2	5	2350	8.29	0.45
Thacker Bed.	1	1	2430	4.42	1.39	Montevallo Bed.	1	4	2330	7.24	0.76
Upper Hance Bed.	1	4	2330	4.74	1.61	Nickel Plate Bed.	1	5	2620	4.73	0.75
<b>TENNESSEE</b>						Pratt Bed.	1	7	2430	5.49	1.59
Angel Bed.	1	1	2160	5.80	1.94	Thompson Bed.	3	10	2230	8.85	0.52
Battle Creek Bed.	2	3	2520	9.68	1.52	Upper Straven Bed.	1	2	2340	7.45	0.88
Billygoat Bed.	1	1	2600	3.26	1.12	Yellow Creek Bed.	3	5	2370	13.90	2.91
Blue Gem Bed.	14	23	2100	3.32	1.34	Youngblood Bed.	2	6	2130	8.62	1.08
Bon Air No. 2 Bed.	8	21	2180	10.27	3.24	<b>VIRGINIA</b>					
Castle Rock Bed.	2	2	2260	10.78	2.68	"B" Bed.	1	1	2420	17.73	2.21
Catoosa Bed.	1	3	2250	7.11	2.59	Big Bed.	3	3	2420	19.89	0.57
Coal Creek Bed.	22	53	2260	6.30	2.37	Big A No. 2 Bed.	1	2	2320	6.34	0.60
Frozen Head Bed.	1	1	2580	6.92	0.92	Big Town Hill Bed.	1	2	2240	11.84	1.48
Grassy Ridge Bed.	1	1	2470	3.75	1.87	"C" Bed.	1	2	2210	10.26	1.40
Hooper Bed.	1	1	2330	2.58	0.69	Clintwood Bed.	1	1	2670	3.26	0.87
Jellico Bed.	14	38	2350	4.95	1.87	Duncan Bed.	1	1	2160	6.65	0.88
Jordan Bed.	3	6	2320	3.33	0.90	Glamorgan Bed.	1	2	2160	5.86	1.22
Kelley Bed.	2	2	2530	7.63	1.33	Imboden Bed.	2	3	2420	11.47	1.56
Lower Dean Bed.	1	1	2340	3.69	0.72	Jawbone Bed.	1	1	2240	19.86	1.03
Mingo Bed.	6	19	2390	4.25	1.27	Kennedy (Widow Kennedy) Bed.	5	8	2190	7.95	1.09
Monarch Bed.	1	4	2320	11.29	2.77	Large Bed.	5	7	+2880	20.19	0.62
Morgan Springs Bed.	2	2	2260	11.05	3.46	Little Bed.	1	1	+3010	21.29	0.49
Mud Slip Bed.	1	1	2640	4.21	0.92	Little Town Hill Bed.	1	2	2440	8.40	0.56
Nelson Bed.	3	7	2340	18.73	1.11	Lower Banner Bed.	3	8	2280	6.37	0.72
No. 4 Bed.	2	5	2220	9.08	3.62	Lower Bolling Bed.	1	1	2720	8.74	1.12
No. 10 Bed.	1	3	2150	11.42	3.14	Meadow Bed.	1	2	2480	12.92	0.62
Old Eagle Bed.	1	1	2290	3.57	1.39	Miller Bed.	1	1	2120	5.89	1.69
Old Etna Bed.	1	1	2140	2.63	0.76	Mohawk Bed.	1	2	2160	3.49	1.32
Paint Rock Bed.	6	6	2420	6.03	1.74	No. 4 Bed.	1	3	2180	6.58	0.49
Poplar Lick Bed.	4	11	+2610	8.36	1.84	Pardee (Parsons) Bed.	1	2	2460	8.04	1.59
Red Ash Bed.	4	13	2570	6.13	1.13	Pocahontas No. 3 Bed.	5	28	2420	4.26	0.54
Rex Bed.	2	10	2230	5.59	1.07	Pocahontas No. 5 Bed.	1	1	2090	5.19	0.82
Richland Bed.	3	6	2590	10.53	0.92	Red Ash Bed.	1	2	2240	5.96	0.64
Rich Mountain Bed.	5	12	2370	3.03	1.29	Small Bed.	1	1	+3010	42.98	0.34
Sandstone Parting Bed.	1	1	2380	10.34	1.26	Splash Dam Bed.	1	2	2720	5.77	0.65
Sewanee Bed.	22	40	2460	10.02	1.20	Upper Bed.	2	2	+3010	29.72	0.38
Soddy Bed.	5	9	2580	6.78	1.16	Upper Banner Bed.	6	20	2420	6.43	0.67
Upper Dean Bed.	1	3	2290	12.02	2.29						
Walden Ridge Bed.	2	2	2580	8.17	0.92						

NOTE:—A plus sign (+) placed before a given value denotes that the true value is above that indicated.



The arrangement in the table of the coal beds in each State is alphabetical. The number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent ash and per cent sulphur in the dry coal are tabulated for each bed tested. Average values for each mine were computed from the individual samples, and from these values averages representing each bed were obtained. It is evident that the greater the number of mines sampled, the more representative are the average values for the beds. This should be kept in mind, as in many instances the average values given for the beds represent only a few mines, and are then not truly representative of the coal bed.

The point taken as the softening temperature is that at which the ash when molded into solid triangular pyramids  $\frac{3}{4}$  in. high and  $\frac{1}{4}$  in. wide at the side of the base, and mounted in a vertical position, has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+3010), and used as such in figuring the average values for the mine from which the average values of the beds were computed.

For convenience in discussion, the order of fusibility of coal ash from the various coals of the country may be divided into three groups, as follows:

Class 1, refractory ashes, softening above 2600 deg. F.

Class 2, ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3, easily fusible ashes, softening at a temperature below 2200 deg. F.

#### CONCLUSION

The coals of Ohio which were tested gave ash of medium fusibility; the average values of the different beds come mainly in class 2. The softening temperatures of the ash from coals of eastern Kentucky and Virginia cover a wide range of fusibility, from readily fusible ashes coming in class 3 to refractory ashes coming in class 1. Many of the coal beds of Maryland which are represented give coal having a refractory ash coming in class 1 or in the upper part of class 2. The coals tested from Tennessee and Alabama come mainly in class 2, giving ash of medium fusibility, though both class 1 and class 3 are represented.

Fuels Chemical Laboratory,  
Pittsburgh Experiment Station,  
Bureau of Mines.

## Legal Notes

BY WELLINGTON GUSTIN

### Who Has Title to This Benzyl Chloride?—Matters of Agency and Title Discussed

IN AN action for the purchase price of 4700 lb. of benzyl chloride and for the cost of 44 carboys purchased at the request of and for the benefit of the defendant, the defendant set up that it acted only as agent of a disclosed principal, M. Naef & Co., of Switzerland. The court said this claim was not sustained by the evidence. The oral contract as testified to by the plaintiff was confirmed by a note written by the defendant, as follows: "We hereby guarantee to pay for 2 tons benzyl chloride 97 per cent at \$1.75 per lb., f.o.b. New York, to be shipped to Messrs. M. Naef & Co., Geneva, Switzerland, as per instructions, upon presentation of bill of lading or dock receipt." (176 N. Y. S., 850.)

The substance of this note is the agreement of defendant to pay upon presentation of the documents. The use of the word "guarantee" does not necessarily import a secondary obligation, said the court. It is only an inference that might be drawn from the use of that term to indicate that the defendant was acting as agent for the Swiss firm. There is nothing on the face of the contract to indicate such to be the fact. It takes more than this to require the determination, as a matter of law, that plaintiffs, in the troubled times of war and the uncertainty of ocean transportation, were entering into a contract with a foreign house, said the court. At the most it was a question of fact for the jury to determine, and it having decided that the Swiss house was not a principal its verdict on that point was not disturbed.

#### PROVISIONS OF THE CONTRACT

The contract provided that the price was to be paid upon presentation of a bill of lading or dock receipt; but there was evidence that the defendant, not having received shipping instructions, directed the plaintiffs to

place the goods in a public warehouse for it and to "bring up the documents." This was a warehouse receipt, and it is upon an alleged compliance with this direction that the plaintiffs recovered a judgment for the price of the goods in the lower court. Now, on Aug. 30, 1915, the merchandise was on storage under a non-negotiable warehouse receipt issued to plaintiffs. The plaintiffs tendered this receipt to defendant and demanded a fulfillment of the contract. The defendant refused to accept the receipt, claiming the goods already to be its property. It made the additional claim that such refusal was justified on two grounds, first, because the plaintiffs had already defaulted and the defendant had rescinded, and second, because the receipt was non-negotiable.

#### RULINGS OF THE COURT

To the first claim the court answered that there had been no default on plaintiffs' part. For on Aug. 13, the defendant required a sample of the goods to be submitted to a chemical test, and told the plaintiffs that the test would require a week or 10 days. Thereafter, on the 16th, the defendant appeared with a certified check for the purchase price, which he tendered to plaintiffs and demanded immediate performance. The inference is reasonable that the defendant, having learned that plaintiffs had not the goods then, made the tender for the purpose of putting plaintiffs in default. On this point the court held that the plaintiffs, in the circumstances, had a reasonable time for compliance, and that the demand without notice was ineffective.

As to the second claim of defendant the court said that since it was agreed that the delivery should be made by a delivery of the warehouse receipt, it could be made as well by a non-negotiable as a negotiable receipt. To place defendant in possession of the goods, a written order by plaintiffs, as well as the non-negotiable receipt, was necessary. But the refusal to accept, on the ground that the goods were the property of the defendant, waived all other objections which could have

been obviated at the time. Said the court: "As the objection that plaintiffs had defaulted rested on an unreasonable tender and demand by defendant, not made in good faith for the purpose of carrying out the contract, but in an artificial attempt to put plaintiffs in default, so the objection that a non-negotiable receipt would not give defendant possession without a written order is an afterthought without substance."

However, said the court, the case turns on the question of title to the goods. If the plaintiffs offered a warehouse receipt that covered their own goods, the tender was sufficient to pass title. If the goods were already the property of the defendant, or if the plaintiffs did not own them, the tender was obviously ineffective. The fact that plaintiffs had possession is presumptive evidence of ownership, but the presumption may be rebutted. On Aug. 16 these goods were on storage with the Continental Warehouse Co. under a negotiable receipt issued to the Behre Chemical Works, which manufactured the goods. On the same day that receipt was voided and another issued to the Franco-American Chemical Co. The defendant offered evidence that it had purchased the goods from the Franco-American company and paid for them. The plaintiffs, under a writ of replevin, seized the goods, took them from the custody of the Continental Warehouse Co., stored them in the Knickerbocker warehouse, obtained a warehouse receipt for them, and tendered it to defendant in fulfillment of the contract.

#### POSSESSION ONLY A PRESUMPTION OF OWNERSHIP

Plaintiffs' possession of the goods establishes only a presumption of their ownership. Plaintiffs took the goods from the possession of the defendant by a writ of replevin which is provisional only and does not determine ownership in itself. The plaintiffs claim that they bought the goods from the Behre Chemical Works, which manufactured them; that the defendant secretly diverted them to itself by connivance with the chemist of the Behre Works; that by several pretended sales, one by the Behre Works to a man named Brett, another by Brett to the Franco-American company, another by the Franco-American company to defendant, the appearance was created that defendant owned the goods, having acquired title from the Behre company; but that as matter of fact the plaintiffs had secured title to the goods from the maker, and none of these acts and sales could divest their title; but they offered no evidence sufficient to establish the crucial fact—that is, that they obtained title from the Behre Chemical Works.

#### PLAINTIFFS HAD NO TITLE TO PASS

Were these charges true, it would indicate as truth what the lower court referred to as defendant defeating plaintiffs' performance with the purpose of cutting out their profits. But this was not an issue in the case. This action was for the price of goods sold. In it the plaintiffs must show that the sale passed the title from them to the defendant. On this crucial test the court held that the evidence was lacking to show that they had any title to pass. The plaintiffs did not show a contract with the Behre Chemical Works whereby they obtained title to the goods. No witness was called from that company. Certain telephone conversations between the parties to this suit were not evidence of the point here involved. Therefore the court granted a new trial to clear up title.

#### Fumes and Gases From Smelter

In an action to recover damages for injuries to growing crops and live stock alleged to have been caused by fumes and gases from defendant's smelter, the Supreme Court of Kansas held that the facts were sufficient evidence to sustain the findings and judgment for plaintiff. (179 Pacific, 342. Courtney vs. American Zinc, Lead & Smelting Co.)

From the facts it appears that plaintiff was in possession of a 12-acre tract adjoining defendant's smelter on the east which he had rented for a number of years and upon which there was growing an acre of strawberry plants, a number of bearing grapevines and various other crops. On another tract near by were bearing peach trees and an orchard. Three or four blocks west of the smelter he owned several lots upon which there were growing strawberry plants. Another tract of 40 acres was used by plaintiff as a pasture.

The petition alleged and plaintiff's evidence tended to prove that smoke and fumes were blown over each of these tracts at different times and that smelter smoke contains sulphur, arsenic, lead and zinc in various combinations, all of which are likely to poison animals and to destroy growing vegetation.

Defendant contended that because plaintiff's evidence showed that his strawberry plants were in excellent condition when they were mulched down in the fall of 1916, the jury was not justified in arbitrarily saying that they must have been injured by something from the smelter because they did not produce a good crop in 1917. It further contended that its demurrer to the evidence should have been sustained because of the absence of any evidence that the animals died from any poison that came from the smelter and because of the testimony of plaintiff's two veterinarians, who were careful not to state their positive opinions, on cross-examination, that the animals died from smelter poisoning.

The court, however, said these two witnesses were not called to testify as to their opinion upon the disputed fact, but to show that fumes given off by smelters sometimes contain sulphur, arsenic, lead and zinc and their combinations, and that any and all of these might poison animals. It was for the jury to say, in view of all the testimony, including that of the experts, whether or not the symptoms exhibited by the animals were caused by smelter poisoning.

#### THE RULE OF LAW APPLICABLE

The court announced the rule of law applicable: "A plaintiff sustains the burden of proof when he shows that at the time his plants were destroyed and damage suffered the defendant's factory was freely emitting fumes, gases and acids which are destructive of plant life, and that the wind was blowing the fumes, etc., toward his premises, some 900 ft. distant, and that there was no other known agency of destruction existing in the vicinity."

It was further urged that the evidence of the veterinarians, that in their opinion the stock in the vicinity of the smelter had been made sick from smoke and fumes from the smelter, was incompetent without proof that the smoke and fumes contained deleterious substances, or until there was expert evidence showing zinc, lead or sulphur emanated from the stacks. The court held it unnecessary to show the precise nature of the gases and fumes which came from the stacks of the smelter.



## Synthetic Cast Iron\*

A Continuous Process of Rapid Carburization During Melting of Steel Turnings, Producing Cast Iron and Semi-Steel of Exceptional Purity and Exact Chemical Analysis for Manufacture of Heavy Shells and High-Grade Castings

By CHARLES ALBERT KELLER

**S**YNTHETIC cast iron is the term by which, since the commencement of its manufacture in the electric furnace, the author has always described the iron obtained by the recarburizing melting of steel turnings. This term has since passed into metallurgical currency, and has now become generic.

The novelty of the manufacture of "synthetic cast iron" consists in carburizing iron and steel scrap, and more particularly turnings, by melting these materials in the presence of carbon, which is introduced simultaneously with them in the melting appliance. The electric furnace is plainly indicated as best fulfilling all the conditions required for the carrying out of this metallurgical operation.

From the outset of the manufacture of steel in the electric furnace there had been obtained, incidentally and without any practical importance being attached to it, the carburization of steel to cast iron composition. Apart from this, and indeed long before it, the process of carburizing iron up to saturation point was well known. No advantage was, however, derived from these facts, as the carburization of a bath of steel in a covered-in furnace, obtained by the various known methods of carburization, such as the introduction of dense conglomerates of carbon and iron (carburite) or pressed blocks of carbon and cast iron, was only practiced with the object of obtaining steel, and moreover, these processes are neither convenient, practicable, nor economical when carburization is carried to the extent of producing cast iron. Only a process of continuous carburization, effected during the course of melting a mixture of steel turnings and carbon,<sup>1</sup> could conduce to an economic method of producing synthetic cast iron with a commercial future capable of development as other than a mere war emergency.

### ADVANTAGES OF CONTINUOUS CARBURIZATION

The preliminary melting of steel turnings in a bricked-in furnace necessitates, indeed, the consumption of an amount of energy corresponding with the temperature which has to be developed in order to melt the steel. It must further be remembered that the thermal efficiency of a furnace of this type is lower than that of an open type furnace constantly replenished with materials for melting, and the walls of which are much cooler. On the other hand, charging turnings into a closed-in furnace, with doors, involves technical difficulties. These disadvantages are, however, but small in comparison with those accompanying the actual carrying out of the carburization in the two instances. The carburization of turnings, after melting, can only be effected by solution brought about between the upper

layers of the metal and the carburants. It becomes the more difficult and the slower, the higher the percentage of carbon rises. The dense carburants employed are expensive, and the consumption of energy resulting from the slowness of the carburization becomes considerable. As the furnace has to be emptied after each heat, there must likewise be taken into consideration the heat losses inseparable from this operation, as well as the repairing of the hearth, sides and roof, none of which arises in the continuous running of an open furnace.

In an electric furnace charged with steel turnings mixed with carbon the carburization is not only absolutely controlled by the known reactions of the substances present, but it should be noted, as an important economic advantage, that the combination of the carbon with the iron begins in the upper parts of the charge long before actual fusion. Cementation intervenes from a temperature of 650 deg. upward and becomes more rapid in proportion as the temperature rises, owing to the descent of the charge.

Carburization of the iron takes place subsequently, by the contact between the solid carbon and the partially carburized metal in the course of melting, and becomes complete on full melting, the temperature of which is determined by the nature of the iron, so that casts can readily be obtained in the electric furnace at temperatures of 1200 to 1300 deg. C.

The proper working of the process in the electric furnace involves, however, other considerations. The mixture of steel turnings and carbon possessing, in itself, very high conductivity, it would become necessary, to insure normal working in the electric furnace, to use so low a potential that higher currents than those ordinarily in use must be employed. On the other hand, it would be a pity to employ electric fusion without profiting by the metallurgical advantages involved, in order to effect desulphurization. The introduction of basic slag into the charge meets these two requirements and accomplishes two results, subsidiary and supplementary to the carburization and necessary to the complete practical success of the process, namely:

(1) The lowering of the conductivity of the mass to be treated by the introduction of a non-conducting material among the conductive materials (turnings and carbon), thus enabling fusion to take place under ordinary thermo-electric conditions, and

(2) Complete and easy desulphurization of the resulting metal.

Thus carried out, the process may be described, from the metallurgical point of view, in the following terms:

The iron obtained in the presence of a sufficiently basic slag, which combines with the small amount of silica introduced, will contain practically all the substances contained in the charge, except the sulphur. There will be no increase in the silicon, and the carbon in the charge will be used up solely in carburization, without

\*Abstracts from a paper read before the Iron & Steel Institute (British), September, 1919.

<sup>1</sup>French patent, Charles A. Keller, No. 405277 of Nov. 10, 1908, and certified addition No. 19358 to patent of Sept. 11, 1913, and English patent No. 22692 of Oct. 8, 1913.

any appreciable intervention of the silica. White cast iron can thus easily be obtained with ordinary steel turnings. With turnings containing 0.44 per cent of silicon, 0.55 per cent of manganese, and 0.07 per cent of sulphur, a white iron of the following composition was obtained:

	Per Cent		Per Cent
Carbon.....	3.55	Manganese .....	0.48
Silicon.....	0.52	Sulphur .....	traces

Hence control of the percentages of silicon and of other elements becomes easy; for example, extra silicon will result from introducing more silica into the charge, along with a corresponding amount of carbon for reducing it. The percentage of silica in the slag will vary according to the percentage of silicon in the iron.

The certainty with which the above considerations can be relied upon allows of the process of manufacture described by the author being regarded as complying absolutely with the predetermined calculation of the charge, and as corresponding absolutely with the estimated amount of the elements contained in it. He can afford a proof of the truth of this conclusion by adducing an instance of an electric furnace with a capacity of 80 to 100 tons per 24 hr., which has not given rise, over a month's working and while specially watched for that purpose, to variations exceeding 0.25 in the results of carburization and of siliconization respectively.

#### HELP OF CHEMICAL LABORATORY NECESSARY

It will have been thoroughly understood from what has been said that control of the composition of the slag must be strictly exercised; also that the amount of carbon introduced must be accurately known. The process, being one of great accuracy, is correspondingly highly sensitive. It is necessary, therefore, to rely entirely on the help of the chemical laboratory.

The carbon employed for carburizing should correspond, so far as its physical condition is concerned, with the size of the steel turnings, so that the contact between the particles may be as perfect as possible, and so as to facilitate carburization in the higher portions of the furnace charge. Small coke is highly suitable, and so is wood charcoal. Either may be used, according to price and to the degree of purity sought.

#### SIMPLICITY OF OPERATION

The system that has been described is one of extreme simplicity. It does not require any skilled workman, as the results sought are independent of any technical manipulation except in so far as the preparation of the charge is concerned, and depend entirely on an accurate knowledge of the composition of all the components.

The electric furnace, fed continuously by the charge, works regularly and with very small losses, as the heat transmitted by the electric hearth situated immediately beneath the charge is, to a very large extent, utilized in heating up the materials, and effects a preliminary carburization prior to melting. This enables the consumption of electrical energy to be reduced to as little as 675 kw.-hr. per ton of pig in a 2500-kw. furnace of 80 to 100 tons. Maintenance of a furnace, working in the manner described, is barely appreciable, seeing that with a six months' campaign at Livet the above furnace did not require any repairs either to linings, shell, or any other part. The lining only needed some attention when the furnace was put out of action owing to the water power supply failing.

The author feels it unnecessary to emphasize too minutely the advantages arising from the profound difference that exists between obtaining casting metal by the slow carburization of previously melted metal by contact between carbon and the bath (solution of carbon in liquid steel), and obtaining casting metal by the method described, based more especially on contact, at a high temperature, between solid or pasty metal and solid carbon. They are determining factors both from the standpoint of economics and of metallurgy.

#### ECONOMIC CONSIDERATIONS

The fundamental economic considerations in the manufacture of synthetic pig are as follows:

1. The electrode consumption can be lowered to as little as 6 kg. per ton, with electrodes of good quality.
2. The consumption of unoxidized turnings is 1050 kg. per ton of iron, a figure which, even with moderately rusty scrap, becomes only a little over 1100 kilograms.
3. The amount of coke with 80 per cent fixed carbon required to produce a ton of strong pig iron with 3 per cent carbon and 1.75 per cent silicon, starting with normal turnings of shell steel, is about 80 kilograms.
4. A furnace of the 80- to 100-ton type should be provided with mechanical appliances for upkeep and charging, so that its operation does not require more than fifteen workmen, for the preparation of the charge by hand, for charging, and for regulating the furnace.
5. Tapping, and loading on trucks as required, need seven men per unit, and handling in the stockyard another two men.

#### COMMERCIAL APPLICATIONS OF SYNTHETIC CAST IRON

The general economy of the process, combined with the simplicity of the method of carrying it out, leads the author to believe that while synthetic iron found a very wide field of application during the war, owing to the very large production of steel turnings derived more particularly from shell manufacture, it will find no less a field after the war in, for example, producing those steel-like qualities of material required for highly resistant mechanical parts.

The most obvious plan to adopt is to lay down a foundry for such parts adjacent to the synthetic cast-iron plant, as has been done at Livet. In such a case the foundry iron from the primary furnace may, if preferred, be made use of by transferring it to an electric mixer which can mix several casts and thus keep any quantity of metal ready for castings.

The manufacture of malleable cast iron is likewise easily accomplished in the electric furnace, as the general quality of the steel turnings enables the low percentage of silicon and manganese required to be readily obtained, the reduced percentage of carbon present being dependent on the composition of the charge. It will also be seen that synthetic iron may find a further field of application in the manufacture of special pig, by means of special additions, such, for example, as nickel, chromium, etc. In such cases benefit will be derived, in making this kind of iron, from the absence of hydrogen, nitrogen, carbonic oxides and occluded air.

The materials required for national defense were generally confined to cast irons whose purity, in regard to phosphorus, corresponded practically with that of the steels used in the production of synthetic cast iron, seeing the sources whence these steels were derived. After the war the situation will be altered. Steel turnings will



come from a variety of sources, and will no longer be under the same guarantees, so that very often it will be their dephosphorization which will be of chief importance when a cast iron of high quality is required.

#### DUAL PROCESS FOR DEPHOSPHORIZATION

The metallurgical value of the results obtained by the process alter completely when it becomes a question of dephosphorization, which the author has practically accomplished by means of a dual process.

In the first place, the steel turnings are melted in the presence of a small quantity of carbon and of a basic oxidizing slag. It is necessary to aim at a critical carburization which must be as high as possible, in order to lower the temperature of working and to facilitate the casting of the metal, while at the same time effecting dephosphorization. A percentage of 1 or slightly over realizes this object.

This first-stage dephosphorized metal, containing low percentages of silicon and manganese, is, according to circumstances, either cast into small ingots which are subsequently melted in an open furnace, mixed with the necessary additions of carbon and a desulphurizing slag composed of materials containing exceedingly little phosphorus, or else poured into a second furnace of the bricked-in type, and covered with a layer of anthracite for recarburizing. The synthetic cast iron produced is controlled in respect of its silicon and manganese percentages by the addition of oxides and of a corresponding amount of reducing carbon, in the ordinary way. This mode of working somewhat increases the cost of production during the first phase, and further necessitates, in the second phase, a converting-cost equivalent to that of manufacturing ordinary synthetic cast iron. About 1500 kw-hr. must be allowed for the two operations.

The higher costs of manufacture are balanced by the higher value conferred on the synthetic cast iron by reason of its extreme purity in regard to phosphorus, and likewise its purity from sulphur and its uniform composition in respect of silicon and manganese. From the commercial point of view such material can compete with Swedish iron.

#### ALTERNATIVE PROCESS FOR STEEL FROM STEEL TURNINGS

The author concludes this account of the chief metallurgical results obtained with synthetic cast iron by describing an alternative process which he has been led to contemplate in connection with the manufacture of steel from steel turnings.

As in the preceding example, the steel turnings are melted in an open furnace fed by the charge, but the slag, instead of being oxidizing, is desulphurizing, and the quantity of carbon introduced with the charge should be sufficient to reduce the oxides in the turnings and to carburize the metal to an extent distinctly above the percentage of carbon sought in the steel, so as to facilitate the pouring of the desulphurized metal and to allow of an oxidizing working in the second stage of the operation.

For example, if a steel with 0.5 per cent of carbon be required, the metal in the primary furnace may be poured at 1.5 per cent of carbon. It will, as has been said, have been freed from sulphur during melting.

The secondary operation, which can be either in an open-hearth furnace or in an electric furnace, refines

the metal and brings it to the required carburization, while at the same time dephosphorizing it. It then remains to bring the metal to the proper carbon content in the ordinary way by final additions.

#### OPERATIONS AT KELLER LELEUX CO. WORKS

The production of synthetic cast iron during the war has been considerable. It is not possible for the author to estimate at the moment how much has been produced at works other than those administered by the Keller Leleux Co. at its works at Livet, Nanterre, and Limoges. The production of these three works alone exceeded 150,000 tons, while it should further be pointed out that Nanterre has been devoted to other manufactures within the last eight months. It goes without saying that such an output could not be obtained solely from existing plants, but required a special industrial effort for the creation of new plants.

Early in 1914 a scheme for a works for the manufacture of malleable iron by this electric process was about to be carried out. This was, however, interrupted by the war. Directly after the specifications for projectiles of semi-steel appeared, the author took steps to produce a metal complying with the conditions laid down by the French Ordnance Department. By November, 1914, such an iron had been produced and investigated, corresponding with the following composition:

	Per Cent		Per Cent
Carbon.....	2.9	Phosphorus .....	0.05
Silicon.....	1.75	Sulphur .....	traces
Manganese .....	0.50		

The test results obtained were as follows:

Tensile strength, 50 kg. per sq.mm. (71,000 lb. per sq.in.); impact resistance, 60 blows (equivalent to fall of a 12-kg. tup from a distance of 89 cm. on a test-piece measuring 40 by 40 mm., resting on two knife edges 16 cm. apart, the distance of fall increasing 1 cm. at a time until rupture occurs), whereas the ordnance requirements only specify a minimum of 25 kg. per sq.mm. for the tensile strength and 18 blows (equivalent to 44 cm.)

#### WORKS AT LIVET

The first electric furnace, of 20 tons, was started in 1914. The uniformity of the iron and the tensile qualities obtained led to its being immediately considered from the standpoint of shell manufacture. The Ordnance Inspection Department, after due examination, showed itself favorable, and before the end of 1914 the first series of 220-mm. shells of semi-steel yielded excellent results at the Bourges proof range.

Orders from the Department were the immediate result of these favorable trials. The manufacture of 220-mm. shells of synthetic semi-steel was thus undertaken at Livet on a commercial scale from the commencement of 1915. A complete foundry was erected and furnished with electrical furnaces for the refining of the iron, and the production, which was in the first instance at the rate of 50 shells per day, was raised in 1916 to three hundred 220-mm. shells, together with ten high-explosive 400-mm. shells requiring 55,000 kg. (60 tons) of raw metal.

#### USE OF ELECTRIC MIXER FURNACES

In order to comply with the best practical conditions for running the foundry, the iron obtained in three primary furnaces is run into a ladle of 5 tons and poured into three 7-ton electric mixer furnaces, each taking

400 kw., to reheat the metal if necessary, and in any case to keep it hot during the period that iron is being used, and to check the quality. Despite the very uniform composition of the primary furnaces, a carbon test, which only takes 20 minutes, is carried out by the foundry staff before pouring, in addition to ascertaining the quality by a quench test which serves more particularly to check the silicon.

The mixer-container furnaces for steel are of the Charles A. Keller type, that is to say, they have a roof and doors. The electric current enters by a vertical electrode, and leaves through the conducting hearth, of the reinforced-puddle type (vertical bars plunged into tamped magnesite). A conducting hearth of this description is practically unwearable, being non-susceptible to any cracking (Fig. 1). If the bottom conducting

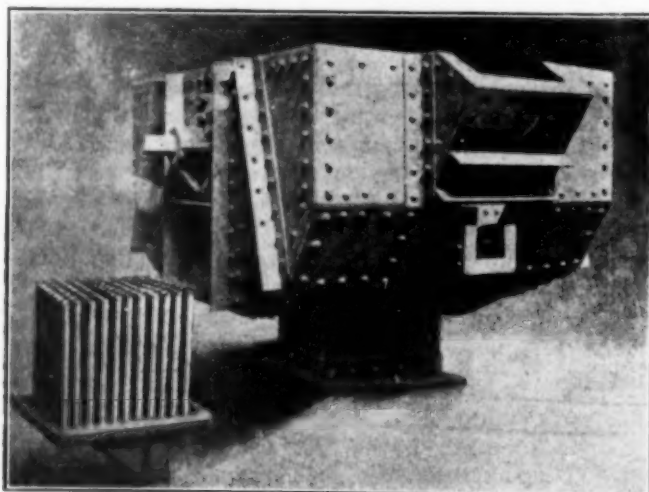


FIG. 1. FURNACE SHELL, CONDUCTING BOTTOM SHOWN SEPARATELY ON LEFT

surface of the hearth wears gradually lower, repairs are very easily effected by spreading over the bottom, while still hot, a special conducting puddle consisting of magnesite and fragments of iron mixed in tar. All holes are thus easily filled up without either the framework or the working of the hearth being interfered with in any way. From a metallurgical point of view this method of repairs corresponds in principle with that employed for the hearths of open-hearth furnaces. The furnaces are, of course, of the tilting type which allows of any quantity of metal, no matter how small, being drawn off.

The liquid iron poured in is covered with basic slag, which forms a protecting layer, preventing oxidation and breaking the electric arc. When pouring is to be done, this layer is easily retained by a little brickwork or sand pocket at the entrance of the furnace spout.

Practice has shown the advisability of interposing these mixer furnaces, which keep the metal so that it can be checked from time to time by the technical staff, who thus acquire a high degree of skill, seeing the ease with which the metal can be held waiting. Generally speaking, it may be said that the metal remains an hour in the mixer furnace, including the time of pouring, for the filling up of these furnaces is carefully adjusted to correspond with casting operations in the foundry. The metallurgical adjustments are very easily carried out, as any additions, as well as the withdrawal of the test samples, are effected through the working door. The practice described gives complete satisfaction; in

particular it invariably insures uniform metallurgical results, thus eliminating all rejections due to insufficient tensile strength.

The upkeep of the mixer furnaces is but trifling. The interior lining of the mixer lasts a couple of months, and the roof over three months. The electrode consumption is on an average 2 kg. per ton of iron; the average power consumption is from 50 to 100 kw-hr. per ton, according to the conditions prevailing in the foundry. A single workman is required for the working of the furnaces, and he also looks after the tapping, the electrical manipulation of the tilting arrangements, and the taking of samples.

#### UNIFORMITY AND GOOD QUALITY OF PRODUCT

The capacity of the electrical foundry at Livet could not keep pace with the output of casting metal, which began at 20 tons per day, was subsequently increased to 60 tons, and later on reached not less than 300 tons during the period of maximum water-power supply. Several outside works manufacturing shell were supplied with the surplus output. These firms all testify to the uniformity and excellent quality of iron supplied. The quality of the iron supplied to outside firms corresponds with the following composition, which complies with the best metallurgical practice: Carbon about 2.75 per cent and silicon about 2 per cent; so that after a cupola melting the artillery specifications could almost be met without any addition of steel, as both recarburization and reduction of silicon accompany fusion in this type of furnace. Each carload sent out was accompanied by an analytical report showing what additions of steel and of ferrosilicon might be needed. Very often no such additions were required.

This method of working usually conduces to obtaining good metallurgical results in shell foundries. The care with which the analyses were made was carried to such a point that qualities specially standardized for carbon and silicon were supplied to smelters in order to check abnormalities due to remelting in certain cupolas.

Even the enlargement of the existing Livet works has now become insufficient to deal with the increased demand for this quality of iron.

#### NEW WORKS AT LIVET

New special works were laid down in November, 1915, some hundreds of yards from the original works, with which they were connected by railway. The new works were started on July 12, 1916, first with a furnace of 80 to 100 tons, and were subsequently enlarged. The building occupied an area of 12,500 sq.m., and comprised more particularly four parallel shops. The first shop, which was 300 m. in length, and was alongside the railway, served for unloading the raw materials and more especially the steel turnings, which are handled by means of a powerful electromagnet suspended from a high-speed crane. The turnings are either used at once in the cycle of operations, or put into stock in a deep trench occupying a portion of the length of the shop, from which they are withdrawn by the same means. By this arrangement a 12-ton car can be unloaded in 20 minutes.

The second shop, which was situated between the unloading shop and the electric furnace shop, served for the preparation of the charges, which are mechanically raised by large bucket elevators to the furnace platform,



where they are tipped on to the latter by small carloads at a time and heaped around the electrodes.

The transformers are housed in sheds built on reinforced concrete foundations on the level of the platform of the electric furnaces. This arrangement possesses the advantage of leaving the second shop entirely free, and also reduces secondary distribution to a minimum. Each shed contains the transformer panelboard which is connected with the central supply by means of an armored cable, leading to a long upper gallery of reinforced concrete, in which are housed the busbars and all the switches (registering meters and watt meters). This gallery, which is just beneath the roof, is capacious enough to allow of easy access, while its position isolates it as completely as possible from dust, and prevents any danger arising to the staff.

The third shop contains five Charles A. Keller furnaces of the "electrodes in series" type arranged in line, four being of 2000 kw. and one being of 2500 kw. (Fig. 2.) The output capacity of this installation is 300 tons of synthetic iron per day. This output could not be maintained, particularly in 1918, owing to various circumstances which were, however, quite independent of the plant itself.

Loading the iron in cars is effected by means of an electro-magnet suspended from an overhead electric crane, which serves a line of railway parallel with the front of the electric furnaces. By this means a 10-ton car can be loaded in 15 minutes.

#### LAYOUT OF THE WORKS

The layout of these works provides for a complete unit of manufacture, in transverse section, for each pair of furnaces, this arrangement being repeated along the whole length, and thus securing the best possible arrangement for the supply of raw materials, and for the removal of the manufactured products, each unit having lines of railway along its sides and being thus connected up with both ends of the works. The haulage of cars is effected by electrical capstans placed throughout the plant. At one end of the works a shop at right angles to the shops just described has been laid down to house electrical converter furnaces to serve a steel foundry. The special synthetic iron employed for this conversion is poured into a ladle on the side of the furnace furthest away from the pig beds. The ladle can thus be conveyed along a longitudinal pit by an electric overhead crane, so that its contents can be poured into the converting furnaces. This arrangement for casting from both of the opposite sides of the electric furnace enables the material to be cast, very conveniently, either into pigs or poured into the ladles.

At the end of the plant are two large shops intended ultimately to serve as rolling mills and to house the accessory appliances.

#### NATIONAL GUN FOUNDRY OF NANTERRE

At the end of 1916 the author was commissioned to lay down and equip the works at Nanterre for an output of 300 tons of synthetic cast iron per day, employing power derived from the sector of the Société d'Energie Electrique de la Région Parisienne.

The electrometallurgical works, known as the National Gun Foundry of Nanterre (Fonderie Nationale d'Artillerie de Nanterre), comprises seven furnaces, of which six are in operation, requiring 10,000 kw. They

were built in 182 effective working days, with the wonderfully active and energetic help of the Société Générale d'Entreprises for all contract work. They were put into operation on July 3, 1917. The works, which were designed for the manufacture of synthetic steely-iron for shell manufacture, at once realized this industrial purpose. The anticipated results were, indeed, surpassed, and the quality of the iron was greatly appreciated by iron-founders on account of its uniformity and purity.

The consumption of materials per ton of pig for the 1650-kw. type of furnace employed was as follows:

Steel turnings, kg. ....	1133	Electrodes .....	6.1
Coke, kg. ....	89-95	Kilowatt-hours .....	\$15

The electrometallurgical works, which were connected to the Havre Railway, comprised an important network of sidings intended to accommodate 40-car trains. The works themselves are composed of three sets of buildings, of which the largest consists of three parallel aisles each of the same length, and the arrangement is practically the same as at Livet, which has already been described. At Nanterre, however, the electric furnace bay and the unloading bay are combined and furnished with a long-span overhead crane, which further accelerates working. The handling arrangements have been

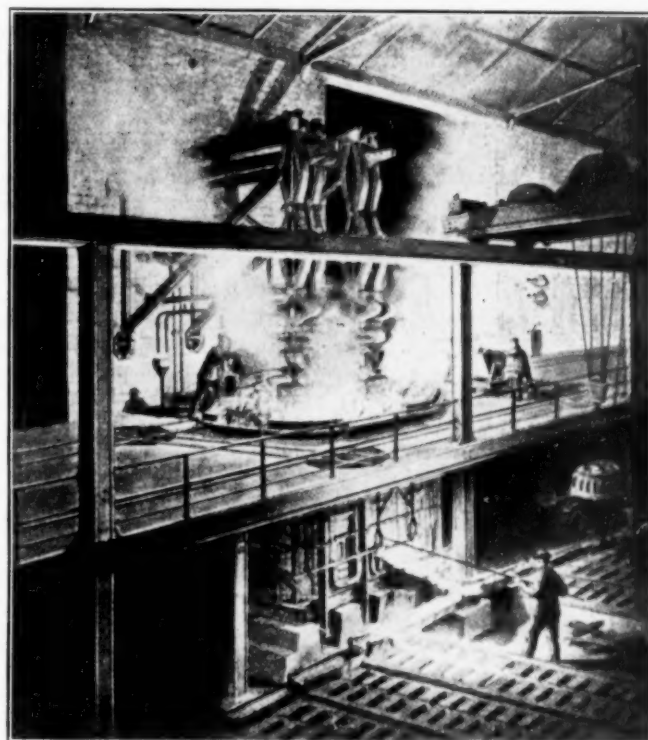


FIG. 2. FURNACE ROOM AT LIVET WORKS

divided into two sections of 150 tons per day, each furnished with an overhead electric crane, for unloading raw materials, with an electromagnet for the turnings and a bucket grab for the other materials, while in the furnace shop there is an overhead crane for loading the pigs. The stocks of steel turnings for current use are stored at the two ends of the third aisle, and are carried to the charge-mixing shop and dropped from the electromagnets into intermediate hoppers made of reinforced concrete. The various materials, such as coke and the slag constituents, are stored in the center portion of the raw materials shop. They are crushed, after unloading from the wagons, and hoisted in large

reinforced-concrete bucket hoppers, whence they are delivered through holes in the bottoms to the trucks. The coke employed for carburization goes from the crusher to a rotary fan drier, which reduces the moisture to less than 1 per cent. Two bins are always in use for holding the coke, one full for current manufacturing purposes and the other in process of being alternately filled. This system allows of the amount of fixed carbon, as coke, which is in course of consumption being accurately known. The charge-mixing shop is adjacent to the raw material storage sheds, and comprises a longitudinal pit in which run the service trucks. These are raised by electric hoists to the electric furnace platform, each hoist serving two furnaces.

#### ELECTRIC FURNACE EQUIPMENT

The electric furnaces are charged by the trucks being tipped on to cast-iron traveling bands, which take the material to the electrodes. The furnaces are built in line at a distance of 30 m. apart from center to center. The transformers are housed in sheds on the level of the charging platform. The distributing system for the 3-phase 5000-v. electric current consists of armored cables carried in a subterranean chamber alongside the longitudinal pit in which the trucks run, so that the manholes open into the side of the pit. Connection with incoming current and with the power station is by means of seven armored cables of 800 sq.mm. in section, of which one serves as a relay.

The electric furnaces are controlled from a control station situated between each pair and is effected by hand, the variations being slight. The arrangements for lowering and raising the electrodes are likewise mechanical. The electric furnaces are of the Charles A. Keller monophase type, with the electrodes in series.

The manufacturing plant proper ends with a shop where the electrodes are prepared, agglomerated in sets of four, the individual rods being connected with the lead-in piece by a fused joint. The blocks so formed are taken by an electric hoist to the smelting shop, and discharged on the end of the electric furnace platform, whence they run on rails to the different furnaces.

In order to provide for future urgent needs the power supply of the electrometallurgical works at Nanterre has been increased to 15,000 kw., to be used in the nine monophase 1560-kw. furnaces housed in a melting shop 175 m. in length.

#### THE LIMOGES WORKS

Simultaneously with the undertakings created at Livet, the Keller Leleux Co., in co-operation with the Société Générale d'Entreprises, established a works for the manufacture of synthetic cast iron, the power supply being the surplus energy developed at the Eymoutiers Hydro-Electric Works, belonging to the Departmental Railway Co. of Haute-Vienne.

The electric furnace, which is one of 1000 kw., was worked in 1916 in parallel with the tramway system, practice having shown that the use of this arrangement is advantageous.

#### VILLEFRANCHE WORKS

A similar plant, the power capacity of which is 2000 kw., has been laid down by the Keller Leleux Co. at Villefranche, to use the surplus power developed by the Midi Co. on its line from Perpignan to Bourg-Madame. This works has only just been completed.

It is incontestable that the war has stimulated ex-

tremely rapid development of the manufacture of synthetic cast iron owing to the abundance of steel turnings and the practical difficulties of using them before 1916, with the result that a considerable quantity of French steel turnings used to be exported, chiefly to Italy and Spain. Since that time blast-furnaces have become large consumers, and the problem of what is their best mode of utilization—either in the blast-furnace or in the electric furnace—now deserves further investigation. Questions of transport now play so considerable a part that in this as in all other cases it is necessary carefully to determine from time to time which is, nationally, the most economic method of using them.

Whichever way the question may be decided, there is no doubt that a recarburizing fusion by electric power derived from water-falls constitutes the most economical mode of utilizing such turnings, in so far as it involves a complete economy of coal. It is therefore toward electrical furnaces supplied by water power that we must look for the utilization of steel turnings, although the post-war conditions may modify the existing situation.

The possibilities connected with the manufacture of synthetic dephosphorized iron must depend in the first place on the supply of steel turnings, but ultimately on the difference between the cost of coal and the cost of developing water power. The whole of the conditions will have to be reviewed later, when war conditions have yielded to conditions of normal equilibrium, but respecting which, for the moment, all forecasts are at present speculative. It will be seen, none the less, that synthetic cast iron has filled a useful gap in the production of pure iron and has rendered valuable help to the cause of national defense.

#### Thermit Welding

An important development of Thermit welding in American shipyards is anticipated by the recent approval by the American Bureau of Shipping of the Thermit process for welding stern frames, rudder frames and other heavy sections on ships registered under its classification. The only qualification is that this Bureau be notified sufficiently in advance to have a surveyor in attendance during the welding operation as well as to inspect and test the weld when completed.

While the Thermit process has been used since 1903 for making marine repairs and has a great many successful welds of this nature to its credit, the process was never officially approved by the American Bureau of Shipping and most of the repairs were made on vessels not classed by it. It is due entirely to the unbroken record of successful marine welds that the Bureau now accords its official sanction to the process. According to a statement by the Metal & Thermit Corporation, there has never been a single failure of a Thermit marine weld so far as it has been able to ascertain in all the years that the process has been used under this company's jurisdiction.

Now that the United States promises to have one of the largest mercantile marines in the world and as practically all of the ships which have recently been constructed and which will be constructed in the future will be registered with the American Bureau of Shipping, the recognition of the Thermit process by that Bureau bids fair to result in many important Thermit marine welds from now on.



## Recent Chemical and Metallurgical Patents

### American Patents

Complete specifications of any United States patents may be obtained by remitting 10c. each to the Commissioner of Patents, Washington, D. C.

**Steel Refining.**—WILLIAM R. WALKER of New York City patents the method of refining basic low-carbon steel by maintaining it in the ladle at a proper pouring temperature for a sufficient time to de-gasify the melt and yet under a slag so modified that rephosphorization will not result. Thus when the open-hearth is tapped the metal runs into a ladle of such size that the most of the slag overflows. The remainder may be skimmed mechanically and replaced by a molten phosphorus-free slag, or if the furnace-slag be low in phosphorus, lime may be added in the runner so it is intimately mixed with that portion of the slag remaining in the ladle, thus increasing its viscosity and consequently decreasing the rephosphorizing action at the surface of the metal. During the time the metal is in the ladle it is kept hot, preferably by electrical currents induced by a high-frequency coil placed about the ladle. (1,309,162; July 8, 1919.) The same inventor patents a quadruplex process for making acid steel of purity comparable to that of Swedish or crucible steel. After bessemerizing in an acid converter to remove nearly all the silicon in the pig, the metal is transferred to a basic open-hearth when the carbon has been reduced to about 0.5 per cent. In this way the phosphorus is removed under the ordinary basic slag of lime and iron oxide. The next step is done in a basic electric furnace, and nearly all the sulphur and remaining phosphorus can be removed under a slag mostly of lime containing from 10 to 35 per cent of silica depending inversely upon the amount of sulphur to be removed. Finally the molten metal is transferred to an acid electric furnace, and worked under a siliceous slag, containing just enough lime for fluidity yet not enough to attack the furnace lining (perhaps 75 per cent  $\text{SiO}_2$ , 25 per cent  $\text{CaO}$  or basic equivalents). This "dead melts" the metal, adding silicon reduced from the slag, which in turn replaces metal in any oxide existing in the bath. When the whole has been sufficiently deoxidized and siliconized, it is tapped and cast. (1,309,496; July 8, 1919.)

**Barium Hydroxide From Barium Sulphide.**—When a solution of barium sulphide of 8 to 10 deg. Bé. at 15 to 20 deg. C. is rapidly cooled with constant agitation until the temperature is reduced to 0 to 5 deg. C., almost pure crystals of barium hydroxide are deposited. These may be purified by washing with a saturated solution of barium hydroxide at the same temperature or by re-crystallization. If, however, solutions of a strength above 10 deg. Bé. be employed, the barium hydrate will be contaminated with barium sulphide in proportion to increasing strength employed. On the other hand, if solutions of a strength below 8 deg. Bé. are used, too small a proportion of pure hydroxide is obtainable. On drying the crystallized barium hydroxide in air which is free from carbonic acid, or *in vacuo*, the dehydrated barium hydroxide  $\text{Ba}(\text{OH})_2$  is obtained in absolutely pure form and can

be used for the production of absolutely pure barium peroxide ( $\text{BaO}_2$ ) by the usual methods. (1,316,133; EDWARD A. BARNES, South San Francisco, Cal.; Sept. 16, 1919.)

**Strawboard Lining for Cyanamide Furnaces.**—Originally the charge of finely ground carbide was introduced into the furnaces in a metal container. The great wear and tear on the metal containers when subjected to the high temperatures used have proved a source of serious trouble and expense, the containers becoming dented and battered through handling, making it difficult if not impossible to discharge the solid cake of cyanamide therefrom. To obviate this difficulty, particularly during the war, when the cost of the metal containers became excessive, a substitute was sought and found, consisting of a paper sleeve which was inserted into the oven and then filled with carbide, after which nitrification was started in the usual manner. This paper sleeve must be manufactured from stout paper and of definite dimensions, and even with the greatest care it would not infrequently tear or split from the pressure of the contained powdered carbide. Further, it was necessary that an annular space be left between the paper and the oven for inserting the proper equipment for placing the paper and holding it in place during filling with carbide, as well as to assist in distribution of nitrogen, and this space appreciably reduced the capacity of a given sized oven and also increased the cost of equipment and housing. By merely lining the furnace with corrugated strawboard, WILLIAM H. MIDDLETON of Niagara Falls, Ontario, finds that a given oven will hold 35 per cent more carbide than when the paper sleeve is used and 50 per cent more than when the metal container is used. The usual cylinder around the resistor is provided and, in addition, tubes of corrugated strawboard extend from the nitrogen inlet to the resistor space and to the top of the charge, so that effective distribution of the nitrogen is obtained. During nitrification the mass sinters and shrinks away from the walls, so that the ingot can be withdrawn by means of two iron hooks placed in the top of the charge before heating. (1,315,678; assigned to American Cyanamid Co.; Sept. 9, 1919.)

**Purification of Partly Oxidized Resins.**—As raw material for producing common resin (colophony), turpentine or natural resin in a fresh state, as obtained by collecting the same from conifers, has hitherto been used. After such collection deposits of old resin are successively formed on the trees, said resin not being adapted to be utilized rationally, since on treating the same according to known methods it gives a colophony of less or no value. This is also the case with old resin flowing out by itself and available to be collected in the woods of conifers. It has been customary to extract the old resin with alcohol, but the resin recovered in this manner is dark colored and only partly soluble in oil of turpentine and linseed oil. JOHN R. KÖHLER of Stockholm, Sweden, finds that the old resin consists of a mixture of oxidized resin acids and crystallized resin acids, both constituents being soluble in alcohol. Such solvents as benzene and oil of turpentine, however, dissolve only the valuable crystallizable resin acids, which may be recovered as light-colored colophony of high quality. (1,316,842; Sept. 23, 1919.)

**Manufacture of Hydrofluoric Acid.**—Fluorspar and sulphuric acid in suitable proportions are fed into a hot stationary inclined still or retort at the upper end through a hopper. In the retort the mixture is kept constantly in motion by revolving paddles, and gradually stiffens as it moves slowly down into the hotter parts. Finally it breaks up, part into powder and part into small balls or rounded lumps. Meanwhile, the reaction between the calcium fluoride and the sulphuric acid goes on, yielding hydrofluoric acid in the form of vapor, and calcium sulphate (CaSO<sub>4</sub>) as a solid residue. The former goes off through a lead pipe, while the residue falls into a water-sealed pit and is removed from time to time in any convenient way. The temperature inside the retort should not be less than 315 deg. C. at the hottest parts. The shaft carrying the paddles may be made hollow to permit cooling by water or other medium. The hydrofluoric acid being given off gradually as the mixture progresses, the process is in effect continuous, even when the raw materials are supplied intermittently. (1,316,569; EDWIN S. FICKES of Pittsburgh, Pa.; Sept. 23, 1919.)

**Synthetic Steel.**—CHARLES A. KELLER of Paris, France, patents a continuous duplex method of making high-grade steel from light turnings or other steel scrap. He uses an open-top shaft furnace with a non-carburizing lining, charging the iron continuously as it settles below the top. With the iron he charges granulated basic slag for desulphurizing, and enough carbonaceous material to reduce any iron oxide present with a surplus to make a fluid high-carbon steel, easily tapped from the furnace. This molten material is then transferred to a closed electric or open-hearth furnace, and held under an oxidizing slag, whereby the carbon is reduced to the required amount. Dephosphorization proceeds simultaneously in this refining furnace. (1,316,724; Sept. 23, 1919.)

## Personal

Captain W. E. BROPHY, formerly of The Barrett Co. and later of the Chemical Warfare Service, U. S. A., has joined the engineering staff of Arthur D. Little, Inc., Cambridge, Mass. In the early part of the war Captain Brophy had charge of the construction and operation of the plant at Astoria, L. I., for the manufacture of high-absorbent carbon for use in gas masks, and later he designed, constructed and operated an additional unit at San Francisco.

HARLAN A. DEPEW, formerly research physical chemist of the Firestone Tire & Rubber Co., Akron, Ohio, is now with the New Jersey Zinc Co., Palmerton, Pa., engaged in experimental work on rubber compounds.

Colonel BRADLEY DEWEY of the Chemical Warfare Service has associated himself with Charles Almy, Jr., in the Dewey & Almy Chemical Co., North Cambridge, Mass., for the manufacture of chemical specialties and mill supplies.

E. W. ENGLEMAN has been appointed consulting research engineer for the Utah Copper, Chino Copper, Ray Consolidated Copper, and Nevada Consolidated Copper companies, with headquarters at Salt Lake City.

Dr. ALEXANDER L. FEILD, formerly with the National Carbon Co., Cleveland, Ohio, is now with the Electro-metallurgical Co., Niagara Falls, N. Y.

Dr. LOUIS J. GILLESPIE, for the past six years investigator in the Department of Agriculture, Washington, D. C., is

now professor of physical chemistry at Syracuse University, Syracuse, N. Y.

J. HARRY HUGHES, of Mobile, Ala., who served in France with the Rainbow Division, has become assistant superintendent for the Ranier Mines Corp., Wenden, Ariz.

G. E. IRONS has left the U. S. Bureau of Standards to accept a position with the American Dresser Tunnel Kilns, Inc., at New Castle, Pa., as thermal engineer.

GRINNELL JONES has severed his connection with the U. S. Tariff Commission to become a member of the faculty of Harvard University, Cambridge, Mass. He is still retained, however, on the staff of the Tariff Commission in a consulting capacity.

Lieutenant ROBERT F. LABARRON, formerly of the U. S. Field Artillery, has joined the staff of Arthur D. Little, Inc., Cambridge, Mass. Mr. LaBarron was sent to Paris after the armistice to the Ecole Supérieure des Mines, at which time he was afforded unusual opportunity to investigate the potash situation in Alsace and the general metallurgical and mining conditions of the Saar Basin with representatives of the French Government.

Dr. IRVING LANGMUIR is to be awarded the William H. Nichols medal at the March meeting of the American Chemical Society, for his paper, "The Arrangement of Electrons in Atoms and Molecules," which is the outstanding contribution to the *Journal of the American Chemical Society*, during the past year.

A. L. MERCER, for several months assistant director of sales of the War Department, has resigned to accept the presidency of the Needham Tire Co., Charles River, Mass. Mr. Mercer entered the Ordnance Department of the Army in 1917 and was commissioned Lieutenant-Colonel in the Ordnance Reserve Corps on his discharge. Prior to his military service he was associated with the B. F. Goodrich Rubber Co., Akron, Ohio.

Dr. ARTHUR W. NIXON has been appointed associate professor of chemical engineering on the faculty of Columbia University, New York City.

CHARLES F. WILLIS has become editor of the *Arizona Mining Journal*, published at Phoenix, Ariz.

WILLIAM W. WINSHIP, American manager of the Thermal Syndicate, Ltd., left on Jan. 3 for a business trip to England to visit the home office at Wallsend-on-Tyne.

C. A. WRIGHT of the Moscow, Idaho, office of the Bureau of Mines, is to succeed F. G. Moses, resigned, as hydro-metallurgist at the Salt Lake City station.

## Obituary

JAMES MCLEAN, vice-president of the Phelps, Dodge Corp. and director of many other companies, died on Jan. 7 of pneumonia.

## Current Market Reports

### The Non-Ferrous Metal Market

*New York, Jan. 5:*—Copper is active at 19½c. for near-by delivery, 19¼@20c. for future delivery. There has been very little trading in tin, the February-March quotation being 61½c. Lead and zinc are both firm.

	Cents per Lb.
Copper, electrolytic.....	19.50
Aluminum, 98 to 99 per cent.....	33.00
Antimony, wholesale lots.....	10.12½
Nickel, ordinary.....	42.00
Nickel, electrolytic.....	45.00
Tin, Straits, spot.....	64.00
Lead, New York, spot.....	8.00
Lead, E. St. Louis, spot.....	7.75
Zinc, spot, New York.....	9.60
Zinc, spot, E. St. Louis.....	9.27½
Silver..... (Dollars per oz.)	1.33

### RARER METALS

Cadmium.....	lb. \$1.50 @ 2.50
Cobalt.....	lb. 1.90
Platinum.....	oz. 150.00
Iridium.....	oz. 250.00
Palladium.....	oz. 150.00
Mercury.....	75 lb. 85.00



## FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled.....	29.00
Copper sheets, cold rolled (over 14 oz.).....	31.00
Copper bottoms.....	37.50
Copper rods.....	30.00
High brass wire and sheets.....	26.00
High brass rods.....	25.00
Low brass wire and sheets.....	28.75
Low brass rods.....	28.75
Brased brass tubing.....	37.25
Brased bronze tubing.....	42.00
Seamless copper tubing.....	35.50
Seamless bronze tubing.....	38.00
Seamless brass tubing.....	32.00

## SCRAP METALS

	Cents Per Lb.
Aluminum, cast scrap.....	23½ @ 24½
Aluminum, sheet scrap.....	22½ @ 23½
Aluminum clippings.....	25½ @ 27
Copper, heavy machinery comp.....	14½ @ 14½
Copper, heavy and wire.....	13½ @ 14
Copper, light and bottoms.....	12½ @ 12½
Copper, heavy cut and crucible.....	15½ @ 16
Brass, heavy.....	7½ @ 8½
Brass, casting.....	10½ @ 10½
Brass, light.....	5½ @ 6½
No. 1 clean brass turnings.....	8½ @ 8½
No. 1 comp. turnings.....	11½ @ 12
Tea lead.....	4.65 @ 4.75
Lead, heavy.....	6.00 @ 6.25
Zinc, scrap.....	4½ @ 4½

## The Iron and Steel Market

Pittsburgh, January 9, 1920.

Visible signs are unabated of a shortage of steel, in consumers scouring the trade for any steel in stock they may uncover or any rolling space for the next 30 or 60 days. In many cases price is scarcely an object, as some manufacturing consumers are losing business through not having enough raw material for full operation. As to late deliveries, there is little interest and the market is quiet. Buyers are not anxious to act for late deliveries at this time, when steel is scarcer than it is assumed it will be later, while the mills are unwilling to sell.

Production of pig iron and steel is increasing at a more rapid rate than was expected. Despite the coke shortage, which was very acute during part of December and is not entirely ended yet, pig-iron production in December was at about 6½ per cent greater rate than in November, while the rate now is about 10 per cent above the December rate. Steel production has gained correspondingly or more. A few steel works are drawing upon pig iron stocks they chance to have. An indication that steel mill operations in the valleys now promise to be heavier in the current quarter than was anticipated is furnished by the fresh buying movement in heavy melting steel scrap in the valleys. In the past week there have been fairly heavy purchases in the district, sufficient to put the market up \$1@ \$2 a ton, heavy melting steel being now quotable at \$26@ \$27, delivered Pittsburgh or valley districts. Some of the valley mills had previously been taking rather a gloomy view of first quarter prospects, estimating their average operation in the quarter at not over about 75 per cent.

Any appraisal of the steel situation and prospects would be altogether incomplete, and perhaps very misleading, if based only upon the present famine conditions existing in steel and without regard to the interesting and important fact that by comparison with present very active conditions in industry generally and with the productive capacity the order books of steel mills are very light. Never before in active times have the steel mills as a whole had such a small volume of business on books in proportion to their capacity as at the present time. The Steel Corporation is sold the farthest ahead, and yet it has some open capacity for second quarter in certain products. So far as is known not an important independent is moderately well filled for second quarter, and many have practically no second quarter tonnage yet entered.

This condition arises from the pursuit of certain policies by the various producers. In general, the mills that have hitherto catered to railroad demand have been reserving capacity for the railroads when they are again joined to their owners. Few institutions have been the subject of so much idle talk in the past few years as the railroads of the United States. It is almost everybody's avocation to talk about railroads without previously seeking informa-

tion, and the talk in some quarters about the railroad companies being unable to place orders involving steel when they regain possession of their lines March 1, on account of the rolling space having been pre-empted by other buyers, has this characteristic. The steel mills have experienced no difficulty whatever in seeing that it is their duty not to leave their former great customer in the lurch when he is restored to the position of being able to offer orders. Railroad business will be taken care of, and at March 21 prices.

In the case of the Steel Corporation a restricted sales policy has been necessary not only for self-protection but for the protection of regular customers, to whom the Steel Corporation purposes furnishing as much steel in the future as in the past, and at March 21 prices. Freely open order books on the part of the Steel Corporation in the past three months would have resulted in its being swamped with orders from all quarters. Then, as to the independents who have adhered nominally to March 21 prices, there has been a hope, probably diminished by now, that the Steel Corporation would advance its prices, and advantage of the advance could then be taken. Some independents have sold scarcely anything of late, and are operating for the present quarter on business held over from 1919 on account of the strike. Other independents, who have advanced prices, have been unable to sell except for early deliveries. Taking the steel industry as a whole, practically all the first quarter output is sold even if the output attains the limit of the most sanguine expectations, but not more than about half the second quarter output, at an outside estimate, is sold. Many reservations or promises, however, have been made.

## MILL OPERATIONS

January opened with steel mills operating at about 80 per cent of capacity, or at the rate of about 40,000,000 gross tons of ingots, or 30,000,000 gross tons of finished rolled steel, a year. Everything is in favor of the rate of operation increasing sharply and no valid reason can be assigned for a prediction that production will be at less than 90 per cent of capacity in March. The discomfort of steel consumers has been so enjoyable to some steel mills, not the majority in point of tonnage capacity by any means, that prospects of better operation have not been regarded with the satisfaction usually obtaining in connection with such an outlook. The philosophy in some quarters appears to have been that it would be enterprising to jack up prices on account of scarcity produced by light operation and then reap the extra profits accruing from full output and a correspondingly lowered cost of production. The United States Steel Corporation's policy in combating this philosophy has been wise and beneficent.

## FERRO-ALLOYS

Domestic producers of ferromanganese have made another \$10 a ton advance, and some have gone another \$10, making present quotations \$140@ \$150, delivered, and on 76 to 80 per cent alloy instead of the former 78 to 82 per cent. English is now held at \$140, c.i.f., though some sales were made recently at \$125. Spiegeleisen has continued to stiffen, being now quotable at \$45, furnace, for spot and \$45@ \$50 for futures.

Electrolytic ferrosilicon is easy, consumers being apparently well covered, with quotations at \$85@ \$90 for 50 per cent and \$140 for 75 per cent, delivered Pittsburgh, valleys and Cleveland. Bessemer ferrosilicon remains at \$59.50 for 10 per cent, \$62.80 for 11 per cent and \$66.10 for 12 per cent, f.o.b. Jackson, Ohio.

## The Chemical Market

New York, January 9, 1920.

The heavy chemical market during the past week has remained firm in price, with little actual trading. Consumers seem to be averse to stocking up beyond immediate need, and at present there is a general scarcity in all lines of material in second hands. Cream of tartar has been in fair demand in small lots and is quoted at 56@ 60c. per lb. Borax continues firm in price since the jump of 1c., and is now being sold at 8½@ 9c. per lb. Roll brimstone sulphur has been active and came up from \$2.95 to \$3.20 per 100

lb., while sulphur sublimed flour jumped from \$3.10 to \$3.35. Inquiries on this item are both foreign and domestic. Epsom salts has been flurrying and is selling at \$2.15 per 100 lb., against a low mark of \$2 for last week. The price on sodium bichromate at present is 19c. per lb., but owing to the rather heavy demand and small supply the market remains uncertain. Demand continues strong on caustic soda and the present supply is reduced to a minimum, while the quotation remains \$4.10@4.35 per 100 lb. A sale has been recorded as high as \$4.40, but the Association price is still fixed at \$4.25. Barium chloride still holds at \$85@90 per ton, while bromine advanced from 65@75c. per lb. of last week to 90@95c. There has been considerable inquiry on iodine resublimed at \$4.10@4.30 per lb. lately. All quotations on alcohol remain nominal and until after Jan. 16 this item will be uncertain both in supply and demand. There is some spot denatured and methyl to be had in small lots but at prices different from those quoted. Formaldehyde has a nominal quotation of 20@45c. per lb., due to scarcity. The solution of the alcohol situation would place this item on a firm footing.

**Coal-Tar Products.**—Demand continues brisk, with most sales being made on forward delivery. Supplies still lag behind and the excessive demand by the automobile trade has not helped the situation. There is a scarcity of crude solvent naphtha. The present quotation is 19@24c. per gal. Dimethylaniline remains firm at 90c.@\$1 per lb., with heavy inquiry. Pyridine at \$2@2.50 per gal. and resorcin at \$3.75@4.50 per lb., are practically unobtainable at present. Paranitrotoluol remains firm at \$1.35@\$1.50 per lb. and toluol is quoted at 29@32c. per gal.

Waxes have been quiet with no change in prices, buying being confined to small orders. Paraffines still lag behind demand and all orders are being made for future delivery. Foreign interest in the paraffines has not let up greatly.

Crude turpentine, sp.gr. 0.900-0.970 jumped from \$1 to \$1.30 per gal. The entrance of the varnish industry as buyer of flotation oil has cramped this market, but the mining industry is still receiving first choice in orders filled.

#### NAVAL STORES

The past week has been classified by one who has been engaged in this industry a number of years as "the busiest week in his experience." Although an individual opinion, it is nevertheless an indication of the steadily increasing activity among the naval stores. Prices seem firm for the time being at least and buyers are not scarce, the only thing to be desired being a settling back to normal conditions among the Southern laborers. There is scarcity of some grades of rosin, noticeably the D-H grades, quoted at \$17.55@\$18.25 per 280 lb. I-K are to be had in spot quantities at \$19.75@\$22 per 280 lb., against \$23 as a high mark for last week.

Turpentine has been rising steadily, and although the demand has not been great, the present quotation is \$1.76 per gal. It is predicted by some that \$2 will be reached before a break will occur. The supply has improved greatly during the past week. A reason advanced for the high price is the condition of the London market, where the price has already reached \$2. There is no available spot to be had in England.

Linseed oil is coming back to normal, the current price being \$1.77 per gal. For the past few days this item has been resting after the sudden rise. The jump was counteracted by a drop in both domestic and Argentine flaxseed, but with the activity anticipated by the paint industry and the increased construction work, the future looks bright for this market. The activity in price on soya bean oil has been accounted for principally by speculation. Many contracts were written last July for January delivery which suddenly increased the demand on this oil. Sellers had been holding off in the hope of easier prices and now to prevent trouble have been buying in large quantities to fill these contracts. The present quotations are, soya bean Manchurian, 19@20c. per lb. and 17½@18c. tank cars f.o.b. Pacific coast.

Crude rubber has been easier, owing to the fact that manufacturers have not completed their inventories. Para-

upriver, fine, dropped to 48@50c. per lb., against 50@51c. of last week. Plantation-first latex crepe came down from 54½c. to 53½c. per lb.

#### ORES AND SEMI-FINISHED PRODUCTS

The ores and semi-finished products continue firm, with practically no new business in molybdenum. Tungsten was active on inquiry, but there has been nothing of importance outside of that. The quotation at present is \$7.50@\$10 per ton for wolframite. Petroleum coke is quoted at \$14 a ton and the Government prices on foundry and furnace grades still prevail. The transportation difficulties have not been relieved by the cold weather, which has further added to the car shortage, and the freezing over of the Monongahela has shut off another outlet. Production is from 30 to 60 days behind and the holiday season still further curtailed output. Added to this the coke makers have shown a dislike to ending the vacation.

Among the miscellaneous materials barytes still continues active at \$35@\$40 per ton, and there is no immediate relief in sight. Manufacturers of this item will not quote beyond a month, so that a quotation may be changed to meet new circumstances which are constantly arising. Fuller's earth is practically unobtainable at present and the nominal quotation of \$25@\$30 per ton domestic still holds.

St. Louis, January 6, 1920.

Good demand for certain of the heavy chemicals, with the exception of sulphuric and muriatic acids, is reported by local works. There is a feeling of firmness about the market that it lacked a short time before the beginning of the year, and while there have been no appreciable price advances, producers look for the present level to hold good for some time.

Approximately the same amount of contract business was consummated at the beginning of the quarter, and a number of concerns that had been buying on a hand-to-mouth basis since the coal strike changed their tactics and made long-term contracts, undoubtedly on the assumption that prices have dropped as low as they will go. There is still a fair amount of spot business, enough to keep prices up.

**Sulphuric Acid.**—The demand for sulphuric has never gotten back to normal since the coal strike, though several spasmodic attempts have been made to hold it up. The demand is growing slowly, nevertheless, and producers look for it to become normal again by the end of the month. Winter falling-off in drilling operations in several Texas and Louisiana oil fields and the consequent lessened demand for "torpedoes" have had their effect. Fertilizer manufacturers are still taking a large part of the output, on contract this time instead of spot buying. The 60 degree grade is quoted at from \$12@\$14 a ton, according to quantity, a slight falling off in price on the larger purchases; 66 degree is quoted at \$18 a ton. Oleum is quoted at \$25 a ton and is in slightly better demand than the two other grades.

**Muriatic Acid.**—There is a fair movement in this line, though not so good as that of a month ago. Practically only contract business is being done in it at present, though there are a few inquiries. The price remains at \$22 a ton for the 18 degree grade.

**Sodium Sulphate.**—A lessened movement in this branch of the market is reported, though there is enough spot buying to keep the price up, one sale being reported at \$20.50 a ton, though most of the sales were made at \$19.50@\$20.

**Sodium Bisulphate.**—Just as with the sulphate, there is only a fair movement in this department, some deals having been made at as low as \$2.50 a ton, and others at \$3 a ton, a falling off of 20 per cent in the last six weeks.

**Zinc Chloride.**—There is practically no demand for this chemical at all, due to the fact that the present is an off season. The quotation at present for 38 Bé. is 10@10.5c. per lb., but producers look for this price to rise soon.

**Zinc Oxide.**—Demand continues good, with prices firm. Quotations are: Lead free, 9@9½c. per lb.; 5 per cent leaded, 8½@8¾c.; 20 per cent leaded, 8@8½c.; 35 per cent leaded, 7¾@8c.



## General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....lb.	\$0.20	\$0.60 - \$0.65
Acetone.....lb.	2.50 - \$3.00	3.00 - 3.25
Acetic, 28 per cent.....cwt.	5.00 - 5.50	6.00 - 6.50
Acetic, glacial, 99½ per cent, carboys.....cwt.	12.00 - 12.50	13.50 - 15.50
Boric, crystals.....lb.	14½ - 15½	15½ - 16½
Boric, powder.....lb.	14½ - 15	15 - 16
Hydrochloric (muriatic), tech. 20 deg.....cwt.	12 - 12½	2.25 - 2.50
Hydrofluoric, 52 deg.....lb.	11 - 11½	12 - 16
Lactic, 44 per cent tech.....lb.	05 - 06	05½ - 07
Lactic, 22 per cent tech.....lb.	05 - 06	4.00 - 4.25
Molybdc, C. P.....lb.	06 - 06½	07 - 08½
Nitric, 40 deg.....lb.	06½ - 07	08 - 08½
Nitric, 42 deg.....lb.	31 - 32	32 - 35
Oxalic, crystals.....lb.	09 - 10	10 - 14
Phosphoric, Ortho, 50 per cent solution.....lb.	30 - 35	40 - 50
Picric.....lb.	2.20 - 2.40	2.30 - 2.60
Pyrogallol, resublimed.....ton	17.50 - 22.00	-
Sulphuric, 60 deg., tank cars.....ton	-	-30.00
Sulphuric, 60 deg., drums.....ton	-	-
Sulphuric, 60 deg., carboys.....ton	22.00 - 25.00	-
Sulphuric, 66 deg., tank cars.....ton	-	-
Sulphuric, 66 deg., drums.....ton	-	-
Sulphuric, 66 deg., carboys.....ton	-	-
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	25.00 -	30.00 -
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	28.00 -	32.00 -
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	35.00 -	40.00 -
Tannic, U. S. P.....lb.	06 -	1.35 - 1.45
Tannic (tech.).....lb.	-	42 - 55
Tartaric, crystals.....lb.	-	69 - 77
Tungstic, per lb. of WO.....lb.	1.20 - 1.40	-
*Alcohol, Ethyl.....gal.	4.80 - 4.95	5.50 -
*Alcohol, Methyl.....gal.	1.50 -	1.52 - 1.57
*Alcohol, denatured, 188 proof.....gal.	-	80 - 82
*Alcohol, denatured, 190 proof.....gal.	-	76 - 78
Alum, ammonia lump.....lb.	08 - 08½	09 - 09½
Alum, potash lump.....lb.	08 - 08½	18 - 20
Alum, chrome lump.....lb.	15 - 16	02½ - 02½
Aluminum sulphate, commercial.....lb.	01½ - 02	03½ - 03½
Aluminum sulphate, iron free.....lb.	02½ - 03	09½ - 10
Aqua ammonia, 26 deg., drums (750 lb.).....lb.	08½ -	30 - 33
Ammonia, anhydrous, cylinders (100-150 lb.).....lb.	13 - 16½	17 - 17½
Ammonium carbonate, powder.....lb.	-	-
Ammonium chloride, granular (white sal ammoniac).....lb.	12½ - 14	13½ - 17½
Ammonium chloride, granular (gray sal ammoniac).....lb.	12 - 12½	13 - 13½
Ammonium nitrate.....lb.	22 -	06 -
Ammonium sulphate.....lb.	05 -	3.65 - 3.75
Amylacetate.....gal.	-	10½ - 11
Arsenic, oxide, lumps (white arsenic).....lb.	-	-
Arsenic, sulphide, powdered (red arsenic).....lb.	-	-
Barium chloride.....ton	85.00 - 90.00	100.00 - 110.00
Barium dioxide (peroxide).....lb.	22 -	24 -
Barium nitrate.....lb.	09½ - 10½	11 - 12
Barium sulphate (precip.) (blanc fixe).....lb.	03 - 03½	03½ - 04
Bleaching powder (see calcium hypochlorite).....lb.	-	-
Blue vitriol (see copper sulphate).....lb.	-	-
Borax (see sodium borate).....lb.	-	-
Bromine.....lb.	90 - 95	-
Calcium acetate.....cwt.	2.00 - 2.05	2.10 -
Calcium carbide.....lb.	-	04½ - 05
Calcium chloride, fused, lump.....ton	20.00 - 25.00	30.00 - 40.00
Calcium chloride, granulated.....lb.	01½ - 01½	02 - 02½
Calcium hypochlorite (bleaching powder).....cwt.	-	2.50 - 3.75
Calcium peroxide.....lb.	-	1.50 - 1.70
Calcium phosphate, monobasic.....lb.	-	75 - 80
Calcium sulphate, pure.....lb.	-	25 - 30
Carbon bisulphide.....lb.	05½ -	06 - 09
Carbon tetrachloride, drums.....lb.	10½ - 11	12 - 15½
Carbonyl chloride (phosgene).....lb.	-	75 -
Caustic potash (see potassium hydroxide).....lb.	-	-
Caustic soda (see sodium hydroxide).....lb.	-	-
Chlorine, gas, liquid-cylinders (100 lb.).....lb.	05 - 05½	08 -
Cobalt oxide.....lb.	-	1.50 - 1.55
Copperas (see iron sulphate).....lb.	-	-
Copper carbonate, green precipitate.....lb.	-	28 - 31
Copper cyanide.....lb.	-	65 - 70
Copper sulphate, crystals.....lb.	07½ - 08½	09 - 09½
Cream of tartar (see potassium bitartrate).....lb.	-	-
Epsom salt (see magnesium sulphate).....lb.	-	2.15 - 2.20
Formaldehyde, 40 per cent.....lb.	-	20 - 45
Glauber's salt (see sodium sulphate).....lb.	-	-
Glycerine.....lb.	-	24½ - 26
Iodine, resublimed.....lb.	-	4.10 - 4.30
Iron oxide, red.....lb.	-	03 - 20
Iron sulphate (copperas).....cwt.	1.00 -	1.20 - 1.75
Lead acetate, normal.....lb.	-	20 - 23
Lead arsenate (paste).....lb.	-	13 - 17
Lead nitrate, crystals.....lb.	-	30 - 35
Litharge.....lb.	-	09½ - 10½
Lithium carbonate.....lb.	-	1.50 -
Magnesium carbonate, technical.....lb.	-	13 - 14½
Magnesium sulphate, U. S. P.....100 lb.	2.15 - 2.63	2.75 - 3.00
Magnesium sulphate, commercial.....100 lb.	1.75 -	2.00 - 2.50
Nickel salt, double.....lb.	14 -	15 -
Nickel salt, single.....lb.	12 -	15 - 16
Phosgene (see carbonyl chloride).....lb.	-	-
Phosphorus, red.....lb.	-	75 - 90
Phosphorus, yellow.....lb.	-	35 - 37
Potassium bichromate.....lb.	28 - 33	34 - 35
Potassium bitartrate (cream of tartar).....lb.	-	56 - 60
Potassium bromide, granular.....lb.	-	50 - 65
Potassium carbonate, U. S. P.....lb.	60 -	65 - 70
Potassium carbonate, crude.....lb.	25 -	30 -
Potassium chlorate, crystals.....lb.	16 - 20	21 -
Potassium cyanide, 98-99 per cent.....lb.	nominal	35 - 42
Potassium hydroxide (caustic potash).....lb.	28 - 32	35 - 36
Potassium iodide.....lb.	-	21 -
Potassium nitrate.....lb.	19 -	65 - 95
Potassium permanganate.....lb.	-	1.10 - 1.20
Potassium prussiate, red.....lb.	-	-

\*Nominal quotations.

	Carlots	Less Carlots
Potassium prussiate, yellow.....lb.	-	\$0.40 - \$0.70
Potassium sulphate.....ton	\$225.00 -	-
Rochelle salt (see sodium potas. tartrate).....lb.	-	-
Sal ammoniac (see ammonium chloride).....lb.	-	-
Sal soda (see sodium carbonate).....ton	15.00 - 21.00	-
Salt cake (sodium sulphate).....ton	-	-
Silver cyanide.....oz.	-	1.25 -
Silver nitrate.....oz.	-	81½ - 82½
Soda ash, light.....100 lb.	2.05 -	2.25 -
Soda ash, dense.....100 lb.	2.25 - 2.35	2.50 - 2.75
Sodium acetate.....lb.	05½ - 06½	07 - 08
Sodium bicarbonate.....100 lb.	2.35 -	2.75 - 3.00
Sodium bichromate.....lb.	18 - 19	22 - 25
Sodium bisulphate (nitre cake).....ton	3.00 - 8.00	10.00 -
Sodium bisulphite.....cwt.	1.80 - 1.90	2.00 - 2.10
Sodium borate (borax).....lb.	-	08½ - 09
Sodium carbonate (sal soda).....100 lb.	1.40 - 1.55	1.50 - 1.75
Sodium chlorate.....lb.	10 -	12 - 14
Sodium cyanide, 96-98 per cent.....lb.	30 -	31 - 34
Sodium fluoride.....lb.	14 -	15 - 16
Sodium hydroxide (caustic soda).....100 lb.	-	4.10 - 4.35
Sodium hypsulphite.....lb.	-	03½ - 04
Sodium molybdate.....lb.	2.50 -	3.25 -
Sodium nitrate.....100 lb.	3.00 - 3.25	3.75 - 4.00
Sodium nitrite.....lb.	15 - 17	18 -
Sodium peroxide, powdered.....lb.	-	30 - 32
Sodium phosphate, dibasic.....lb.	03½ - 04	04½ - 05
Sodium potassium tartrate (Rochelle salt).....lb.	-	43 - 45½
Sodium prussiate, yellow.....lb.	23 - 39	24 - 40
Sodium silicate, solution (40 deg.).....lb.	01½ - 02	02 - 02½
Sodium silicate, solution (60 deg.).....lb.	02½ - 03	03½ - 04½
Sodium sulphate, crystals (Glauber's salts) cwt.	1.15 - 1.25	1.50 - 2.00
Sodium sulphide, crystal, 60-62 per cent (conc.).....lb.	-	05 - 06
Sodium sulphite, crystals.....lb.	03½ -	04 - 06
Strontium nitrate, crystals.....lb.	25 -	28 -
Sulphur chloride.....lb.	05½ -	06 -
Sulphur, crude.....ton	22.00 -	-
Sulphur dioxide, liquid, cylinders.....lb.	09 -	10 - 12
Sulphur (sublimed), flour.....100 lb.	3.35 -	3.40 - 3.65
Sulphur, roll (brimstone).....100 lb.	3.20 -	3.30 - 3.40
Tin bichloride (stannous).....lb.	42½ -	46 - 50
Tin oxide.....lb.	43 -	60 -
Zinc carbonate, precipitate.....lb.	-	20 -
Zinc chloride, gran.....lb.	12½ -	13½ - 15
Zinc cyanide.....lb.	49 -	50 -
Zinc dust.....lb.	09 - 11	11 - 14
Zinc oxide, dry American.....lb.	-	09½ - 12
Zinc sulphate.....lb.	03½ - 03½	04 - 04½

## Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude.....lb.	\$1.00 -	\$1.10
Alpha naphthol, refined.....lb.	1.40 -	1.50
Alpha naphthylamine.....lb.	34 -	37
Aniline oil, drums extra.....lb.	43 -	48
Aniline salts.....lb.	75 -	1.00
Anthracene, 80% in drums (100 lb.).....lb.	1.75 -	-
Benzaldehyde (f.c.).....lb.	1.10 -	-
Benzidine, base.....lb.	90 -	1.00
Benzidine, sulphate.....lb.	90 -	1.10
Benzoic acid, U.S.P.....lb.	90 -	1.00
Benzoate of soda, U.S.P.....lb.	80 -	1.00
Benzol, pure, water-white, in drums (100 lb.).....gal.	27 -	31
Benzol, 90%, in drums (100 lb.).....gal.	25 -	29
Benzyl chloride, 95-97%, refined.....lb.	35 -	40
Benzyl chloride, tech.....lb.	25 -	35
Beta naphthol benzoate.....lb.	50 -	60
Beta naphthol, sublimed.....lb.	75 -	80
Beta naphthol, tech.....lb.	45 -	55
Beta naphthylamine, sublimed.....lb.	2.25 -	2.35
Cresol, U.S.P., in drums (100 lb.).....lb.	18 -	25
Ortho-cresol, in drums (100 lb.).....lb.	23 -	25
Cresylic acid, 97-99%, straw color, in drums.....gal.	75 -	80
Cresylic acid, 95-97%, dark, in drums.....gal.	72 -	75
Cresylic acid, 50%, first quality, drums.....gal.	60 -	-
Dichlorobenzol.....lb.	07 -	10
Diethylaniline.....lb.	1.40 -	2.25
Dimethylaniline.....lb.	90 -	1.00
Dinitrobenzol.....lb.	26 -	37
Dinitrochlorbenzol.....lb.	25 -	30
Dinitronaphthalene.....lb.	45 -	56
Dinitrophenol.....lb.	32 -	36
Dinitrotoluenol.....lb.	38 -	40
Dip oil, 25%, tar acids, car lots, in drums.....gal.	38 -	40
Diphenylamine.....lb.	58 -	75
H-acid.....lb.	1.60 -	1.75
Metaphenylenediamine.....lb.	1.15 -	1.60
Monochlorbenzol.....lb.	12 -	15
Monoethylaniline.....lb.	1.50 -	1.75
Naphthalene crushed, in bbls. (250 lb.).....lb.	06 -	08
Naphthalene, flake.....lb.	07 -	08
Naphthalene, balls.....lb.	08½ -	10
Naphthionic acid, crude.....lb.	75 -	1.25
Nitrobenzol.....lb.	14 -	19
Nitro-naphthalene.....lb.	30 -	35
Nitro-toluenol.....lb.	27 -	30
Ortho-amidophenol.....lb.	3.00 -	4.25
Ortho-dichlor-benzol.....lb.	15 -	20
Ortho-nitro-phenol.....lb.	90 -	1.25
Ortho-nitro-toluenol.....lb.	25 -	40
Ortho-toluidine.....lb.	25 -	45
Para-amidophenol, base.....lb.	2.50 -	3.50
Para-amidophenol, HCl.....lb.	2.50 -	3.25
Para-dichlor-benzol.....lb.	15 -	18
Paranitraniline.....lb.	1.00 -	1.20
Para-nitro-toluenol.....lb.	1.35 -	1.50
Paraphenylenediamine.....lb.	2.50 -	4.00
Paratoluidine.....lb.	2.00 -	2.50
Phthalic anhydride.....lb.	70 -	1.00
Phenol, U.S.P., drums (dest.), (240 lb.).....gal.	12½ -	19
Pyridin.....gal.	2.00 -	2.50
Resorcin, technical.....lb.	3.75 -	4.50
Resorcin, pure.....lb.	6.50 -	6.75
Salicylic acid, tech., in bbls. (110 lb.).....lb.	45 -	60
Salicylic acid, U.S.P.....lb.	45 -	50
Salol.....lb.	90 -	95
Solvent naphtha, water-white, in drums, 100 gal.....gal.	22 -	27
Solvent naphtha, crude, heavy, in drums, 100 gal.....gal.	19 -	24
Sulphanilic acid, crude.....lb.	25 -	30

Toluidine.....	lb.	\$1.70	—	\$2.50
Toluidine, mixed.....	lb.	.45	—	.55
Toluol, in tank cars.....	gal.	.28	—	.32
Toluol, in drums.....	lb.	.29	—	.32
Xylidine, drums, 100 gal.....	lb.	.44	—	.50
Xylol, pure, in drums.....	gal.	.37	—	.45
Xylol, pure, in tank cars.....	gal.	.35	—	.45
Xylol, commercial, in drums, 100 gal.....	gal.	.37	—	.45
Xylol, commercial, in tank cars.....	gal.	.23	—	.27

### Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow.....	lb.	\$0.42	—	\$0.45
Beeswax, refined, yellow.....	lb.	.47	—	.48
Beeswax, white, pure.....	lb.	.63	—	.68
Carnauba, No. 1.....	lb.	.80	—	.88
Carnauba, No. 2, regular.....	lb.	.65	—	.78
Carnauba, No. 3, North Country.....	lb.	.43	—	.48
Japan.....	lb.	.18	—	.20
Paraffine waxes, crude match wax (white) 105-110 m.p.....	lb.	.06	—	.07
Paraffine waxes, crude, scale 124-126 m.p.....	lb.	—	—	.06
Paraffine waxes, refined, 118-120 m.p.....	lb.	—	—	.09
Paraffine waxes, refined, 128-130 m.p.....	lb.	.09	—	.10
Paraffine waxes, refined, 133-135 m.p.....	lb.	—	—	.12
Paraffine waxes, refined, 135-137 m.p.....	lb.	—	—	.13
Stearic acid, single pressed.....	lb.	.23	—	.26
Stearic acid, double pressed.....	lb.	.28	—	.29
Stearic acid, triple pressed.....	lb.	.32	—	.33

NOTE—Quotations on paraffine waxes are nominal.

### Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp.gr. 0.930-0.940.....	gal.	\$1.30		
Pine oil, pure, dest. dist.....	gal.	—		
Pine tar oil, ref., sp.gr. 1.025-1.035.....	gal.	.40		
Pine tar oil, crude, sp.gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.....	gal.	.35		
Pine tar oil, double ref., sp.gr. 0.965-0.990.....	gal.	.70		
Pine tar, ref., thin, sp.gr. 1.080-1.060.....	gal.	.38		
Turpentine, crude, sp.gr. 0.900-0.970.....	gal.	1.30		
Hardwood oil, f.o.b. Mich., sp.gr. 0.960-0.990.....	gal.	.35		
Pinewood creosote, ref.....	gal.	.49		

### Naval Stores

The following prices are f.o.b., New York, for carload lots:

Rosin B-D, bbl.....	280 lb.	\$17.00	—	\$17.50
Rosin E-I.....	280 lb.	17.85	—	18.40
Rosin K-N.....	280 lb.	19.75	—	22.50
Rosin W. G.-W. W.....	280 lb.	22.50	—	24.25
Wood rosin, bbl.....	280 lb.	17.00	—	17.50
Spirits of turpentine.....	gal.	1.76	—	1.85
Wood turpentine, steam dist.....	gal.	—	—	1.70
Wood turpentine, dest. dist.....	gal.	1.64	—	—
Pine tar pitch, bbl.....	200 lb.	8.25	—	8.50
Tar, kiln burned, bbl. (500 lb.).....	bbl.	14.50	—	14.75
Retort tar, bbl (500 lb.).....	bbl.	15.00	—	15.25
Rosin oil, first run.....	gal.	—	—	.91
Rosin oil, second run.....	gal.	.93	—	.94
Rosin oil, third run.....	gal.	1.10	—	1.12
Rosin oil, fourth run.....	gal.	—	—	1.15

### Solvents

73-76 deg., steel bbls. (85 lb.).....	gal.	\$0.33		
70-72 deg., steel bbls. (85 lb.).....	gal.	.31		
68-70 deg., steel bbls. (85 lb.).....	gal.	.30		
V. M. and P. naphtha, steel bbls. (85 lb.).....	gal.	.23		

### Crude Rubber

Para-Upriver fine.....	lb.	\$0.48	—	\$0.50
Upriver coarse.....	lb.	.35	—	.37
Upriver cauchó ball.....	lb.	.34	—	.36
Plantation—First latex crepe.....	lb.	.53	—	.54
Ribbed smoked sheets.....	lb.	.53	—	—
Brown crepe, thin, clean.....	lb.	.48	—	.48
Amber crepe No. 1.....	lb.	.53	—	—

### Oils

#### VEGETABLE

The following prices are f.o.b., New York, for carload lots:

Castor oil, No. 3, in bbls.....	lb.	\$0.18	—	\$0.19
Castor oil, AA, in bbls.....	lb.	.21	—	.23
China wood oil, in bbls.....	lb.	.23	—	.24
Cocoonut oil, Ceylon grade, in bbls.....	lb.	.19	—	.20
Cocoonut oil, Cochín grade, in bbls.....	lb.	.20	—	.23
Corn oil, crude, in bbls.....	lb.	.19	—	.22
Cottonseed oil, crude (f.o.b. mill).....	lb.	.19	—	.20
Cottonseed oil, summer yellow.....	lb.	.22	—	.27
Cottonseed oil, winter yellow.....	lb.	.24	—	.25
Linseed oil, raw, car lots.....	gal.	1.77	—	1.87
Linseed oil, raw, tank cars.....	gal.	1.70	—	1.80
Linseed oil, boiled, car lots.....	gal.	1.75	—	1.80
Olive oil, commercial.....	gal.	2.50	—	2.60
Palm, Lagos.....	lb.	.16	—	.17
Palm, bright red.....	lb.	.16	—	.17
Palm, Niger.....	lb.	.16	—	.17
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.23	—	.24
Peanut oil, refined, in bbls.....	lb.	.27	—	.28
Rapeseed oil, refined in bbls.....	gal.	1.45	—	1.65
Rapeseed oil, blown, in bbls.....	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.....	lb.	.19	—	.20
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.17	—	.18

#### FISH

Winter pressed Menhaden.....	gal.	\$1.20	—	—
Yellow bleached Menhaden.....	gal.	1.23	—	—
White bleached Menhaden.....	gal.	1.25	—	—
Blown Menhaden.....	gal.	1.26	—	—

### Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, flinted.....	ton	\$35.00	—	\$40.00
Barytes, off color.....	ton	20.00	—	25.00
Blanc fixe, dry.....	lb.	.03	—	.04
Blanc fixe, pulp.....	ton	30.00	—	50.00
Casein.....	lb.	.16	—	.18
Chalk, English, extra light.....	lb.	.05	—	.07

Chalk, English, light.....	lb.	\$ .04	—	\$ .06
Chalk, English, dense.....	lb.	.04	—	.05
China clay (Kaolin), imported, lump.....	ton	25.00	—	35.00
China clay (Kaolin), imported, powdered.....	ton	30.00	—	60.00
China clay (Kaolin), domestic, lump.....	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered.....	ton	25.00	—	40.00
Feldspar.....	ton	13.50	—	18.00
Fluorspar, acid grade, lump, f.o.b. mines.....	net ton	30.00	—	35.00
Fluorspar, acid grade, ground, f.o.b. mines.....	net ton	35.00	—	45.00
Fuller's earth, domestic, powdered.....	ton	25.00	—	30.00
Fuller's earth, imported, powdered.....	ton	35.00	—	40.00
Pumice stone, imported.....	lb.	.03	—	.06
Pumice stone, domestic.....	lb.	.02	—	—
Shellac, TN.....	lb.	1.10	—	1.15
Shellac, D. C.....	lb.	—	—	—
Shellac, V. S. O.....	lb.	—	—	—
Shellac, Diamond I.....	lb.	—	—	—
Shellac, orange, fine.....	lb.	1.25	—	—
Shellac, orange, superfine.....	lb.	1.20	—	1.30
Shellac, A. C. garnet.....	lb.	1.10	—	—
Shellac, bleached, bone dry.....	lb.	1.35	—	—
Shellac, bleached, fresh ground.....	lb.	1.10	—	1.15
Soapstone.....	ton	15.00	—	25.00
Talc, domestic.....	ton	16.00	—	60.00
Talc, imported.....	ton	60.00	—	70.00

### Refractories

Following prices are f.o.b. works:

Chrome brick.....	net ton	80-90 at Chester, Penn.
Chrome cement.....	net ton	45-50 at Chester, Penn.
Clay brick, 1st quality fireclay.....	1,000	35-45 at Clearfield, Penn.
Clay brick, 2nd quality.....	1,000	30-35 at Clearfield, Penn.
Magnesite, dead burned.....	net ton	50-55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.....	net ton	80-90 at Chester, Penn.
Silica brick.....	1,000	41-45 at Mt. Union, Penn.

### Ferro-Alloys

All prices f.o.b. works.

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.....	net ton	\$200.00	—	\$250.00
Ferro-chrome per lb. of Cr contained, 6-8% carbon.....	lb.	.20	—	.40
Ferro-chrome per lb. of Cr contained, 2-4% carbon.....	lb.	.21	—	.50
Ferro-manganese, 70-80% Mn.....	gross ton	140.00	—	150.00
Spiegeleisen, 16-20% Mn.....	gross ton	40.00	—	50.00
Ferro-molybdenum, per lb. of Mo.....	lb.	3.00	—	3.50
Ferro-silicon, 50%.....	gross ton	85.00	—	95.00
Ferro-silicon, 75%.....	gross ton	150.00	—	175.00
Ferro-silicon, 10-15%.....	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W.....	lb.	1.25	—	1.40
Ferro-uranium, 35-50% of U.....	lb.	7.00	—	—
Ferro-vanadium, 30-40% per lb. of contained V.....	lb.	5.50	—	7.00

### Ores and Semi-finished Products

Chrome ore, 35-40%, Cr <sub>2</sub> O <sub>3</sub> .....	unit	\$0.60	—	\$0.85
Chrome ore, 48% and over.....	unit	1.00	—	1.25
*Coke, foundry, f.o.b. ovens.....	net ton	7.00	—	7.50
*Coke, furnace, f.o.b. ovens.....	net ton	6.00	—	6.50
Petroleum coke, refinery, Atlantic seaboard.....	net ton	—	—	14.00
Fluorspar, gravel, f.o.b. mines.....	net ton	—	—	25.00
Manganese ore, 45% Mn and over.....	unit	.50	—	.75
Manganese ore, chemical (MnO <sub>2</sub> ).....	gross ton	60.00	—	70.00
Molybdenite, 85% MoS <sub>2</sub> , per lb. of MoS <sub>2</sub> .....	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO <sub>3</sub> and over, per unit of WO <sub>3</sub> .....	unit	9.00	—	15.00
Tungsten, Wolframite, 60% WO <sub>3</sub> and over, per unit of WO <sub>3</sub> .....	unit	7.50	—	10.00
Uranium oxide, 96%.....	lb.	2.75	—	3.00
Vanadium pentoxide, 99%.....	lb.	6.00	—	—
Pyrites, foreign, lump.....	unit	.17	—	—
Pyrites, foreign, fine.....	unit	.17	—	—
Pyrites, domestic, fine.....	unit	.16	—	.17
Ilmenite, 52% TiO <sub>2</sub> .....	lb.	.02	—	—
Rutile, 95% TiO <sub>2</sub> .....	lb.	.11	—	—
Carnotite, minimum 2% U <sub>3</sub> O <sub>8</sub> , per lb. of U <sub>3</sub> O <sub>8</sub> .....	lb.	2.75	—	3.00
Zircon, washed, iron free.....	lb.	.10	—	—
Monazite, per unit of ThO <sub>2</sub> .....	unit	42.00	—	—

\* Government prices.

### Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

#### BUILDING MATERIALS

Portland cement, at dock, without bags.....	bbl.	\$2.80		
Lump lime, common, including container.....	300 bbl.	2.65		
Common brick, at dock.....	M.	16.00		
Yellow pine, 3x4 to 8x8, 20 ft. and under.....	M.	48.00		
Yellow pine, 3x4 to 8x8, 20 ft. and under at Chicago.....	M.	50.00		
Yellow pine, 3x4 to 8x8, 20 ft. and under at St. Louis.....	M.	40.00		
Roofings, tar felt (14 lb. per 100 sq. ft.).....	ton	70.00		
Roofings, tar pitch (in 400-lb. bbl.) carlots.....	ton	21.00		
Roofings, asphalt pitch carlots.....	ton	34.00		
Roofings, asphalt felt carlots.....	ton	63.00		
Roofings, slate-surfaced, per roll of 108 sq. ft. carlots.....	—	2.25		
Roofings, slate-finished shingles, 100 sq. ft. carlots.....	—	6.00		
Linseed oil, raw in barrels.....	gal.	1.75		
Linseed oil, 5 gal. cans.....	gal.	1.90		
Red lead, dry, 100 lb. keg.....	lb.	.13		
Red lead, in oil, 100 lb. keg.....	lb.	.14		
Red lead, dry, 5 lb. cans.....	lb.	.15		
Red lead, in oil, 5 lb. cans.....	lb.	.15		
White lead, dry and in oil, 100 lb. keg.....	lb.	.13		
White lead, dry and in oil, 25 and 50 lb. kegs.....	lb.	.13		
White lead, dry and in oil, 5 lb. cans.....	lb.	.15		

#### STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.....	100 lb.	\$2.45		
Angles, 3 to 6-in., ½-in. thick.....	100 lb.	2.45		
Tees, 3-in. and larger.....	100 lb.	2.45		
Plates.....	100 lb.	2.66		
Rivets, structural, ½-in. and larger.....	100 lb.	4.20		
Rivets, conehead for boilers, ½-in. and larger.....	100 lb.	4.30		
Sheets, No. 28 black.....	100 lb.	4.35		
Sheets, No. 10 blue annealed.....	100 lb.	3.55		
Sheets, No. 28 galvanized.....	100 lb.	5.70		

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.



# INDUSTRIAL

## Financial, Construction and Manufacturers' News

### Construction and Operation

#### California

**EL MONTE**—The city voted \$55,000 bonds to construct a sewerage system and septic tank. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, engr.

**LOS ANGELES**—The Mathews Paint Co., 219 South Los Angeles St., has awarded the contract for the construction of a 2-story, 99x99-ft. paint factory on San Fernando Rd. to J. V. McNiel, 736 H. W. Hellman Bldg. Estimated cost, \$40,000.

**MODESTO**—The city voted \$30,000 bonds to construct a sewage disposal plant. G. H. Freitas, city engr.

**STOCKTON**—The Natl. Paper Products Co. is preparing plans for a fireproof addition to its mill. Estimated cost, \$1,000,000.

#### Illinois

**CHICAGO**—The Chicago Coated Board Co., 11 South La Salle St., plans to build a plant at Cottage Grove Ave. and 138th St. Estimated cost, \$3,000,000.

**CHICAGO**—R. G. Pierce, archt., 10 South La Salle St., will soon receive bids for the construction of a 1-story, 75x80-ft. factory at East 94th St. and Commercial Ave., for the United States Graphite Co., 80 East Jackson Blvd. Estimated cost, \$25,000. N. Ronneberg, 10 South La Salle St., engr.

#### Iowa

**DANVILLE**—The Sugar Creek Creamery Co. has awarded the contract for the construction of a 2-story addition to its plant, to the Clark Construction Co., Danville. Estimated cost, \$50,000.

**CORYDON**—The city will soon award the contract for the construction of a filter and settling basin, also for furnishing filter house equipment, etc. A. T. Gallagher, city clk. M. G. Hall, civil and sanitary engineer, Centerville, engr.

#### Maryland

**LAMCELLE** (Cumberland P. O.)—The American Cellulose & Chemical Mfg. Co. plans to build a large addition to its plant. Guy Leonard, genl. mgr.

**CURTIS BAY** (Baltimore P. O.)—The Union Acid Wks. will be incorporated to construct a plant to cost \$1,000,000; same to have daily capacity of 200 tons of sulphuric acid. A site of 7 acres has been purchased adjoining the plant of the Standard Acid Wks. Address George A. Whiting, Continental Bldg., Baltimore.

#### Michigan

**DETROIT**—The Detroit Graphite Co., 12th St., engaged E. R. Dunlap, archt., 209 Hammond Bldg., to prepare plans for the construction of a 2-story paint factory on Linsdale Ave. Estimated cost, \$30,000.

#### Mississippi

**BROOKHAVEN**—The Mayor and the Board of Aldermen will receive bids until Jan. 20 for the construction of a sewerage system, including a disposal plant. Chester Byrne, city clk., M. L. Culey, Jackson, engr.

#### New York

**BROOKLYN**—Knoor Bros., 1116 Wyckoff Ave., will build a 1-story, 80x90-ft. brass foundry on Cooper Ave., near the tracks of the Long Island R.R. Estimated cost, \$30,000. Work will be done by day labor.

**COLLEGE POINT** (Flushing P. O.)—J. B. Kleintner Rubber Co., 725 Broadway, New York City, will soon award the contract for the construction of a 4-story factory. Estimated cost, \$150,000. R. G. Cory, 39 Cortlandt St., New York City, archt. and engr.

#### New Jersey

**DOVER** (Piscataway)—A. Niles, commanding officer, Dover Arsenal, will soon receive bids for remodeling and reconstructing certain buildings here for experimental plant

for chemicals for Ordnance Bureau. Estimated cost, \$4,000,000 and \$5,000,000.

**TRENTON**—The Ajax Rubber Co., Breunig Ave., plans to construct a 3-story, 60x350-ft. rubber plant. Estimated cost, \$39,000. H. M. Baer, 101 Park Ave., New York City, archt. and engr.

#### Ohio

**CLEVELAND**—The Acorn Refining Co., 8001 Franklin Ave., will soon award the contract for the construction of a 4-story, 40x105-ft. factory. Estimated cost, \$60,000. E. M. Katz, pres.

**CLEVELAND**—The Paramount Brass Co., 1391 East 33rd St., has awarded the contract for the construction of a 1-story, 40x120-ft. brass factory at 1391 East 33rd St., to H. G. Slatmyer, 203 Lakeside Ave. Estimated cost, \$10,000.

#### Oklahoma

**LAWTON**—The Lawton Star Refinery, recently organized, plans to build an oil refinery on a 15-acre tract just north of the Fair Grounds. Estimated cost, \$100,000. F. A. Parkinson, pres., G. S. Hallman, mgr.

#### Pennsylvania

**WILKES-BARRE**—The Diamond Drug Co. is preparing plans for the construction of a 3-story, 22x180-ft. drug factory on Northampton St. Estimated cost, \$170,000.

#### Tennessee

**MEMPHIS**—The University of Tennessee, College of Medicine, 718 Union, plans to build a laboratory on Madison Ave., for the City Hospital, which it controls. Estimated cost, \$100,000. H. A. Morgan, Nashville, pres.

#### Wisconsin

**SHEBOYGAN**—The Porcelain Enameling Association plans to remodel and rebuild part of the 4-story 60x150-ft. factory on Lake Shore Rd., recently destroyed by fire. Estimated cost, \$20,000. Address W. J. Vollroth, 82 West 6th St.

#### Ontario

**OWEN SOUND**—The Bd. Educ. plans to construct a 13-story collegiate institute. Ratepayers voted on \$180,000 bylaw to raise money for same. Chemical and physical laboratory equipment will be installed in same.

**SARNIA**—The Lake Huron Steel Corp. has purchased a 1,100-acre site along the St. Clair River and plans to construct a steel plant on same, to have a capacity of 100,000 tons of alloy steel annually. Estimated cost, \$10,000,000. S. A. Howard, engr.

**TORONTO**—The Prest-O-Lite Co., Inc., 120 Elm St., has awarded the contract for the construction of a 3-story plant, on Hillcrest Race Course, to Wells & Gray, Confederation Life Bldg. Estimated cost, \$400,000.

### Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold its annual meeting in Philadelphia, Pa., Feb. 23-26. Headquarters are at the Bellevue-Stratford Hotel.

THE AMERICAN CHEMICAL SOCIETY will hold its annual meeting April 13 to 16 inclusive, in St. Louis.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting in Boston, April 8, 9, and 10.

THE AMERICAN ELECTROCHEMICAL SOCIETY, New York Section, will hold a meeting, Jan. 23, on "Cheap Cyanide and Its Disposition."

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting in New York, Feb. 16-19.

THE NATIONAL FOREIGN TRADE CONVENTION will be held in San Francisco, May 12 to 15.

### Industrial Notes

THE RICHARDSON-PHENIX Co., Milwaukee, Wis., has opened a Birmingham, Ala., office, in charge of James D. Scruggs.

THE BESSEMER LIMESTONE & CEMENT Co., Youngstown, Ohio, announces that it has taken over all the properties of the Bessemer Limestone Co. and is successor to it.

W. L. SAVELL and J. G. G. FROST, formerly general supt. and chemical supt., respectively, of Metals-Chemical, Welland, Ont., Canada, have opened a consulting office at 732 Frankfort Ave., Cleveland, Ohio, under the firm name of Savell & Frost.

ARTHUR D. LITTLE, INC., which designed, erected and put into operation the plant for the production of rosin, turpentine and pine oil from pine stumps for the National Reduction Corp. at Calvert, Ala., has turned it over to the owners as a going concern. It is of especial interest at this time in view of the demand for the reclamation for agricultural purposes of the cut-over lands of the South. Arthur D. Little, Inc., also announces that its experimental paper mill, which has been busy for some months on demonstrations of the paper-making quality of linters and cotton hull fiber which, during the war, were the chief sources of cellulose for the nitrocellulose used in smokeless powder, is now engaged on the commercial production of the acid-washed filter paper for quantitative chemical analysis formerly imported. Its capacity for this purpose is more than sufficient to meet the entire American demand and to insure the highest possible quality of product. The mill is operating on distilled water.

THE QUIGLEY FURNACE SPECIALTIES Co., New York City, announces that after several years, experimenting with alloys and special steels for heat treating, it is putting on the market a complete line of carbonizing pots and annealing boxes for heat treating. These products are made of a special analysis known as Q-steel, designed for maximum resistance to oxidation, coupled with minimum cost per heat-hour of service. In addition to the low priced steel boxes and special castings, the company will market two high-grade alloys for similar work where the operating conditions will make this class of material more economical. The department of heat treatment will be under the management of H. H. Harris.

PERCY SCOTT LEGGATT, of Summerson & Co., Darlington, England, has been investigating the iron and steel possibilities on the coast at Vancouver, B. C., with the view to erecting an electric smelting plant there. Mr. Leggatt claims to have the capital behind him if he can obtain the necessary ore and power concessions. The furnaces would be made by his firm in England and sent to Vancouver knocked down.

A. P. Gillis, on behalf of the TIVANI ELECTRIC STEEL Co., of Belleville, Ont., claims that he has arranged the purchase of a \$5,000,000 bond issue for the erection of an electric iron and steel plant of a capacity of 200 tons per day if the citizens of Vancouver will guarantee the interest on the bond issue for a number of years and will guarantee 50,000-hp. continuous service at \$10 per hp.-yr.

THE VANCOUVER ENGINEERING WORKS, Vancouver, Canada, is installing an electric furnace for the production of special steels to be used in the construction of machinery that the company manufactures.

THE AMERICAN CONSTITUTIONAL LEAGUE has been organized by influential business men in Milwaukee, for the promotion of Americanization work. This will embrace all forms of education and publicity in favor of Americanism and in opposition to radicalism. Frank R. Bacon, president of the Cutler-Hammer Mfg. Co., Milwaukee, has been elected chairman of the new organization.

THE JARECKI CHEMICAL Co. of Cincinnati, Ohio, is rebuilding its plant, which was partially destroyed by fire last September. The Austin Co. has the contract for rebuilding this plant, the main portion of which is a special electric crane type fertilizer plant, 135 x 540 ft., to be used for acidulating, curing and storing chemical fertilizer and will run approximately \$400,000 in cost. Gustav Jarecki is president.

THE INTERSTATE COMMERCE COMMISSION has declared unreasonable the rates on fertilizer from Mobile, Ala., to various stations on the Southern Pacific lines in Louisiana. These rates were attacked in a case brought by the Virginia-Carolina Chemical Co.

THE INTERNATIONAL OXYGEN CO., with main offices at Newark, N. J., is establishing a new branch plant at Toledo, Ohio, to furnish oxygen and hydrogen for all purposes to the numerous manufacturers and industries in that industrial section using either one or both of these gases in their processes. The capacity of the plant will be 3,000,000 cu. ft. of gas per month, the purity of which is said to be 99.5 per cent and higher.

FRANK H. NICKLE, manufacturer of agitator driving yokes, a standard power transmission device for driving agitator or stirrer shafts in open or closed chemical tanks, kettles and other containers, announces the organization of the Nickle Engineering Works, with office and factory at 729 North Niagara St., Saginaw, Mich. The company will install additional machine shop equipment and increase the scope of operations.

LAWRENCE M. BRILE, who has been connected for the last five years with the United Smelting & Aluminum Co., Inc., as vice president and sales manager, severed his connection with that company on Jan. 1, on which date he assumed the presidency of Brile & Ratner, Inc., a New York corporation, formed to engage in the metal and chemical brokerage business. Mr. Brile will take charge of the non-ferrous metal end of the business, while Mr. Ratner will take charge of the chemicals department. Temporarily, the office of Brile & Ratner, Inc., will be located at 115 Broadway, New York City.

THE JERRY JOHNSON 100-TON CYANIDE MILL at Cripple Creek is being dismantled by the Morse Bros. Machinery & Supply Co. of Denver. This mill, erected in 1914 and used but a few months, was completely equipped with Dorr thickeners, agitators and classifiers, Oliver filter, etc. The material is being shipped to Denver for resale.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, announces that the Atlas Machinery & Supply Co. is now handling the sale of the American steam ash conveyor in St. Louis territory. This company has offices at 1416 Syndicate Trust Bldg., St. Louis, Mo., and is a new sales organization in that vicinity headed by William H. Patton, who recently returned to the United States after two years service in the Army.

THE N. P. PRATT LABORATORY, one of the oldest chemical laboratories in the South, has sold its entire analytical department, together with its good will. Its successor will be known as Brogdon-Dumas Laboratories, Inc. The concern will do a general chemical engineering practice, including the making of all kinds of assays and analyses. J. S. Brogdon has conducted a commercial chemical laboratory in Atlanta for the past eleven years. W. C. Dumas, former state chemist of Georgia, more recently chief chemist of the N. P. Pratt Laboratory, has during the past thirteen years at various times been connected with the N. P. Pratt Laboratory. Additional space has been secured adjoining the old laboratory of J. S. Brogdon at 70½ Peachtree St., Atlanta, Ga. The union of these two laboratories makes a most complete chemical equipment.

## New Publications

THE SCIENTIFIC AMERICAN PUBLISHING CO., 233 Broadway, New York City, announces that beginning with Jan. 1, 1920, the *Scientific American Supplement* will be changed in form and in period of issue. The new journal will be published on the first of each month, and will be known as the *Scientific American Monthly*.

THE BANKERS TRUST CO., of New York, has just published a brochure, "Financial Status of Belligerents," by Louis Ross Gottlieb, setting forth authoritatively and interestingly the debt, revenue and expenditure, and the note circulation of the principal belligerents in the World War.

THE GEOLOGICAL SURVEY OF GEORGIA has just issued a preliminary report on the oil prospect near Scotland, Telfair Co., Ga., by J. P. D. Hull and L. P. Teas.

THE PORTLAND CEMENT ASSN. is distributing a booklet entitled "Concrete Tanks for Industrial Purposes."

THE THIRD ANNUAL REPORT of the United States Council of National Defense for the fiscal year ended June 30, 1919, has just been issued.

A STUDY OF THE FORMS IN WHICH SULPHUR OCCURS IN COAL. By A. R. Powell and S. W. Parr. Bull. No. 111, Engineering Experiment Station, published by the University of Illinois, Urbana, Ill.

"SECURING BETTER COMBUSTION OF MID-WEST, WESTERN AND SOUTH WESTERN FUELS"

is the title of a booklet issued by the Green Engineering Co., East Chicago, Ind., which contains eight articles taken from *Electrical World and Power*.

THE SALES MANAGER'S BUREAU of the St. Louis Chamber of Commerce has published a pocket-size trade directory comprising a classified list of manufacturers and jobbers in the district.

THE EXPERIMENT STATION of the Hawaiian Sugar Planters Assn. has issued a bulletin (No. 45), published at Honolulu on "The Paper Making Qualities of Hawaiian Bagasse," by Arthur D. Little, Inc., of Cambridge, Mass. It contains a general survey of the question, a discussion of previous attempts to use bagasse as paper-making material, description of the principal paper-making processes, discussion of the technique involved in handling Hawaiian bagasse with reference to the experimental results obtained, the commercial aspect of making paper in Hawaii from bagasse and the class of product which might be made, estimates of production and costs and tabulation of experimental data. The report followed the successful design and construction of a mill in Hawaii now in operation making a soft paper felt from bagasse which is used as a protection against weeds in the sugar cane fields under the Eckert patents. By this means about 50 to 70 per cent of the labor costs are saved, and the yield is increased. The sharp, stiff cane sprouts break through the felt, while the soft-topped woods curl up and die.

THE THIRD ANNUAL REPORT of the United States Tariff Commission has just been issued.

"AMERICAN AND INTERNATIONAL LABOR CONDITIONS" is the title of a new booklet which gives a complete report of the proceedings of the Fall National Conference held under the auspices of the Society of Industrial Engineers, Cleveland, Ohio, Oct. 29 to 31, 1919.

ANNUAL REPORT OF THE DIRECTOR, BUREAU OF STANDARDS, to the Secretary of Commerce for the fiscal year ended June 30, 1919, has just been published by the Department of Commerce, Washington, D. C., and is known as Miscellaneous Publication No. 40.

SMELETER TREATMENT RATES. Bull. No. 30, published by the Canada Department of Mines, Ottawa, which is the report of the Committee of Investigation in the matter of tolls charged by the Consolidated Mining & Smelting Co. of Canada, Ltd., at Trail, B. C., June, 1919.

Compressed Air Magazine appears in new form and style with the issue for January, 1920. Announcement is made in that issue of the fact that the magazine is entering upon its twenty-fifth year. W. L. Saunders has been editor in chief from the beginning, but now retires to be succeeded by Francis Judson Tietz as editor and general manager. Other members of the staff are Eugene P. McCorken, managing editor, formerly assistant editor of *Engineering and Mining Journal*, and Frank Richards as technical editor.

THE FEDERAL BOARD FOR VOCATIONAL EDUCATION has issued its third annual report.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONS I: 5 "Silver, Copper, Lead and Zinc in the Central States in 1918," Mines report, by J. P. Dunlop and B. S. Butler (Mineral Resources of the U. S., 1918, Part I), published Oct. 31, 1919; I: 7, "Quicksilver in 1918," by F. L. Ransome, with a supplementary bibliography by Isabel P. Evans (Mineral Resources of the U. S., 1918, Part I), published Oct. 31, 1919; I: 8, "Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1918," Mines report, by Charles W. Henderson (Mineral Resources of the U. S., 1918, Part I), published Nov. 6, 1919; I: 9, "Arsenic, Bismuth, Selenium, and Tellurium in 1918," by James M. Hill (Mineral Resources of the U. S., 1918, Part I), published Nov. 19, 1919; I: 19, "Platinum and Allied Metals in 1918," by James M. Hill (Mineral Resources of the U. S., 1918, Part I), published Dec. 8, 1919; II: 14, "Fluorspar and Cryolite in 1918," by Ernest F. Burchard (Mineral Resources of the U. S., 1918, Part II), published Dec. 9, 1919; II: 17, "Silica in 1918," by Frank J. Katz (Mineral Resources of the U. S., 1918, Part II), published Dec. 4, 1919; I: 23, "Manganese and Manganiferous Ores in 1917," by D. F. Hewett (Mineral Resources of the U. S., 1919, Part I), published Oct. 31, 1919; I: 24, "Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1917," Mines report, by Charles W. Henderson (Mineral Resources of the U. S., 1917, Part I), published Nov. 8, 1919; II: 12, "Gypsum in 1918," by Ralph W.

Stone (Mineral Resources of the U. S., 1918, Part II), published Nov. 6, 1919; II: 13, "Sand and Gravel in 1918," by R. W. Stone (Mineral Resources of the U. S., 1918, Part II), published Oct. 31, 1919; II: 15, "Peat in 1918," by C. C. Osborn (Mineral Resources of the U. S., 1918, Part II), published Nov. 24, 1919; II: 35, "Coal in 1917. Part B: Distribution and Consumption," by C. E. Leshner (Mineral Resources of the U. S., 1917, Part II), published Nov. 18, 1919; Bull. 700, "The Analysis of Silicate and Carbonate Rocks" (A revised and enlarged edition of Bull. 422), by W. F. Hillebrand.

NEW BUREAU OF STANDARDS PUBLICATIONS: Scientific Paper 346, "Oxygen Content by the Ledebur Method of Acid Bessemer Steels Deoxidized in Various Ways," by J. R. Cain and Earl Pettijohn, issued Nov. 11, 1919; Sci. Paper 347, "Heat Treatment of Duralumin," by P. D. Merica, R. G. Waltenberg and H. Scott, issued Nov. 15, 1919; Sci. Paper 350, "Equilibrium Conditions in the System Carbon, Iron Oxide and Hydrogen in Relation to the Ledebur Method for Determining Oxygen in Steel," by J. R. Cain and Leon Adler, issued Nov. 10, 1919; Tech. Paper 137, "Coking of Illinois Coal in Koppers Type Oven," by R. S. McBride and W. A. Selvig, issued Nov. 17, 1919; Tech. Paper 141, "Electrolytic Resistance Method for Determining Carbon in Steel," by J. R. Cain and L. C. Maxwell, issued Dec. 6, 1919; Tech. Paper 146, "Cadmium Electrode for Storage Battery Testing," by H. D. Holler and J. M. Braham, issued Dec. 12, 1919; Ninth annual report by the director of the Bureau of Mines to the Secretary of the Interior, for the fiscal year ended June 30, 1919.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 162, "Removal of the Lighter Hydrocarbons From Petroleum by Continuous Distillation," by J. M. Wadsworth; Bull. 181, "Abstracts of Current Decisions on Mines and Mining, Reported From January to May, 1919," by J. W. Thompson; Tech. Paper 211, "Approximate Quantitative Microscopy of Pulverized Ores, Including the Use of the Camera Lucida," by Will H. Coghill and J. P. Bonardi; Tech. Paper 234, "Sensitiveness of Explosives to Frictional Impact," by S. P. Howell.

## Manufacturers' Catalogs

THE LAW METALLIC PACKING CO., INC., New York City, has issued a pamphlet on "Law Metallic Packing."

WILLIAM R. PERRIN & CO., Chicago, Ill., calls attention to a booklet illustrating and describing filter presses for beet or cane sugar refineries.

THE FRANKLIN MANUFACTURING CO., Franklin, Pa., is distributing Catalog FC 7-19, on heat insulations, covering 78 pages. Less than one-half of this pamphlet deals with the Franklin Mfg. Co. products specifically; the rest constitutes a complete and useful handbook on the subject of heat insulation. Complete tables, diagrams, instructions and illustrative examples are given so that the proper kind and correct thickness of pipe covering can be determined for any set of conditions.

THE SCHUTTE & KOERTING CO. has issued a pamphlet recently entitled "Our Part in the War." Copies will gladly be sent to those applying.

THE UNITED STATES CONDITIONING AND TESTING CO., New York, has issued a pamphlet entitled "Tests and Analyses," which includes a price list of tests and analyses on dyestuffs, oils, soaps, rubber goods, paper, silk, cotton, wool, and fibers. The company maintains a chemical department which is prepared to analyze soaps, oils, raw materials, dyestuffs, chemicals, etc.

THE ELECTRIC FURNACE ASSN., Niagara Falls, N. Y., has issued a booklet on "Steel."

THE BACHARACH INDUSTRIAL INSTRUMENT CO., Pittsburgh, Pa., has recently issued two pamphlets. Pamphlet P summarizes the extended experience in the field of Pitot tubes and orifices; pamphlet F describes a new pressure-volume indicator, suitable for permanent installations or testing purposes.

THE DENVER FIRE CLAY CO., Denver, Col., calls attention to its attractive catalog on Melting Furnaces, known as Bull. 450, which illustrates and describes tilting furnaces, gas-fired furnaces, a motor blower, a combination burner, an oil furnace, etc.

GUYTON & CUMPER MFG. CO., of 4451 Fillmore St., Chicago, has issued Bulletin No. 101 covering steam-jacketed pumps and steam-jacketed pipe-fittings. This bulletin contains various illustrations of the pumps and accessories and tables with the necessary dimensions for design and erection.